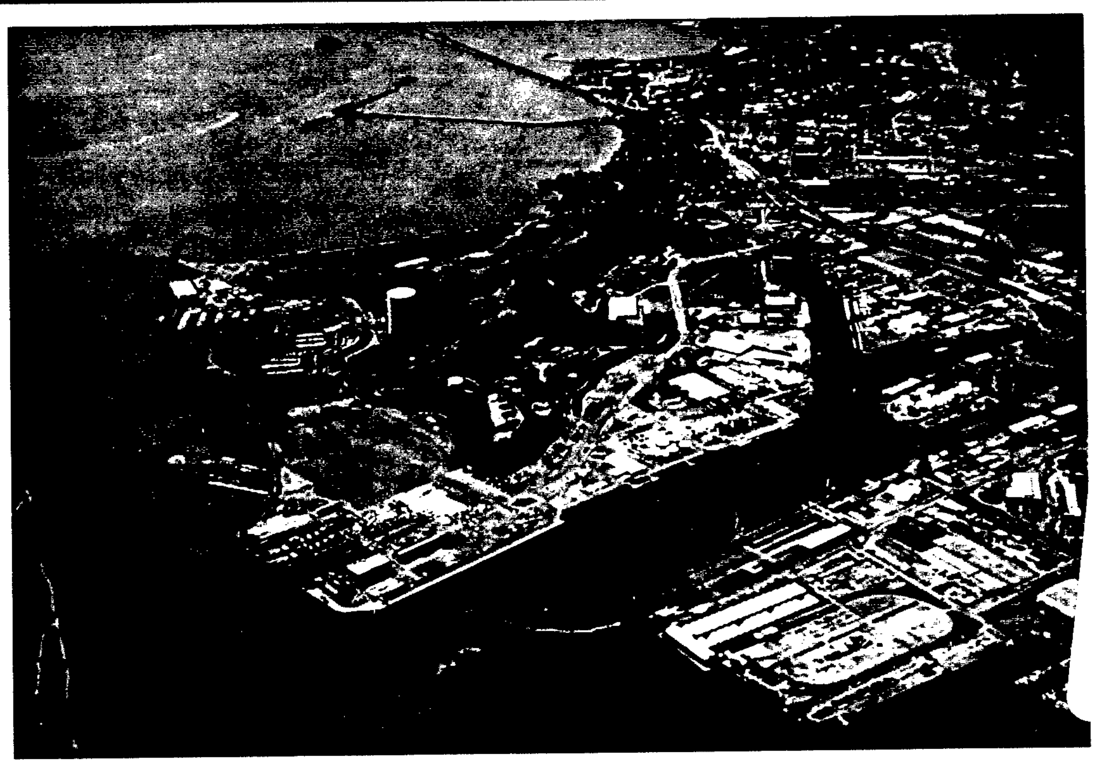
U.S. Army Corps
of Engineers
San Francisco District

RICHMOND HARBOR
Contra Costa County, CA

Navigation Improvement Project
General Design Memorandum



January 1996

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The Richmond Harbor Navigation Improvement Project located in Richmond, California, will create a safe, navigation channel of sufficient depth for modern bulk carriers scheduled to use the Port's terminal facilities. The project area includes a channel extending from the Long Wharf Maneuvering Area through the Richmond Entrance Channel, the Potreto Reach and Sharp Turn with a turning basin at Point Potrero, the Inner Harbor, and the Santa Fe Channel. Furthermore, the existing 35-foot-deep channel has sharp turns that are increasingly difficult for large vessels to navigate, especially against strong winds, waves and currents, at night and under foggy conditions. The recommended plan for navigation improvement would deepen the existing 4.0 nautical miles of the Richmond Harbor channel from -35 feet mean lower low water (MLLW) to -38 feet MLLW. The plan includes a new 1,200-foot turning basin at the Potrero Sharp Turn. The Corps proposed a two-phase channel improvement plan to meet the Port's present and future needs, while avoiding the expenditure of funds before the full dimensions of the project are required. The recommended Phase I of the project, is designed for bulk vessels (-38 feet MLLW), while Phase II will be designed for containerships (-41 feet MLLW). Construction of Phase II has been deferred indefinitely.

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General Design Memorandum

for

Navigation Channel Deepening

Richmond Harbor
38-Foot Project

FINAL REPORT

Prepared by:

U.S. Army Corps of Engineers
San Francisco District
January 1996

Executive Summary

The purpose of this report is to develop and recommend a plan of improvement for Richmond Harbor located in Richmond, California, that will create a safe, navigation channel of sufficient depth for modern bulk carriers which are scheduled to use the Port of Richmond terminal facilities. Construction of the Richmond Harbor Deepening Project was authorized by the Water Resources Development Act (WRDA) of 1986, 99th Congress, 2nd Session, Public Law 99-662, and previously by the Supplemental Appropriations Act of 1985.

The Port of Richmond has long been a major center of bulk cargo shipments. Waterborne commerce has increased nearly eight-fold in eight years, from 3,015,000 tons in 1986 to 23,800,000 tons in 1993. Commodities shipped through the Port include scrap metal, steel products, steel byproducts, metal ores, gypsum products, chemicals, vegetable oils, and petrochemicals. This project is designed to serve the immediate navigational needs and facilitate continued growth of waterborne commerce.

The project area includes the navigation channel extending from the Long Wharf Maneuvering Area through the Richmond Entrance Channel, the Potrero Reach and Sharp Turn with a turning basin at Point Potrero, the Inner Harbor, and the Santa Fe Channel. The existing 35-foot-deep channel has sharp turns that are increasingly difficult for large vessels to navigate, especially against strong winds, waves and currents, at night and under foggy conditions. As cargo tonnage grows and larger vessels enter the port, the inadequacy of the channel will increase the frequency of light-loading and tidal delays as well as the potential for grounding.

The recommended plan for navigation improvement would deepen the existing 4.0 nautical miles of the Richmond Harbor channel from -35 feet mean lower low water (MLLW) to -38 feet MLLW. A two-phase channel improvement plan is proposed to meet the Port's present and future needs, while avoiding the expenditure of funds before the full dimensions of the project are required. The recommended Phase I of the project, is designed for bulk vessels (-38 feet MLLW), while Phase II will be designed for containerships (-41 feet MLLW). Construction of Phase II has been deferred indefinitely.

The initial channel configurations for Richmond Harbor were optimized by means of a navigation simulation study conducted by the Waterways Experiment Station (WES). This Corps of Engineers agency modeled existing and improved channel conditions (i.e., the turning basin) for vessel size and maneuverability, winds, waves, currents, bottom and bank conditions, visibility, and mode of operation.

The total estimated volume of dredged material for the Richmond project is approximately 1,911,000 cubic yards (CY). Disposal of all new work material considered suitable for unrestricted aquatic disposal (~1,677,000 CY) is proposed for the EPA-designated Ocean disposal site, 52 nautical miles from the Golden Gate Bridge. The remaining 234,000 CY of dredged material is considered unsuitable for unrestricted disposal will be placed at the

Parking Lot site where it will be capped with asphalt. Maintenance dredging will be taken to the existing Alcatraz site if the sediment is deemed suitable for unrestricted disposal. If not, maintenance material will be disposed at an upland site.

The estimated total project cost associated with the recommended Phase I plan is $33,693,000. The estimated total average annual cost including Operations and Maintenance costs is $2,762,000. With estimated total average annual benefits of $4,574,000, the project's benefit-to-cost ratio is 1.7 to 1.

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Relevant Data

Name	Richmond Harbor, California
Authorization	Water Resources Development Act (WRDA) of 1986, Public Law 99-662, Section 202 Supplemental Appropriations Act of 1985
Location	Contra Costa County, California
Purpose	Navigation Improvement
Local Sponsor	City of Richmond, Port of Richmond
Location	East-Central San Francisco Bay near the City of Richmond, California
Length	~4.0 Nautical Miles (nm)
Depth	-38 feet MLLW, with 1 to 2 feet of overdepth
Bottom Width	Varies
Side Slopes	1 Vertical to 3 Horizontal (1V:3H)
Dredging	~1,911,000 cubic yards (CY)
Disposal	~1,677,000 CY - Ocean Disposal Site ~234,000 CY - Parking Lot

ECONOMIC DATA
(rounded)

Total Project First Cost	$33,693,000
Incremental O&M Cost	$42,000
Interest During Construction	$1,090,000
Interest & Amortization (7.625% @ 50-yrs.)	$2,720,000
Average Annual Benefits	$4,574,000
Average Annual Costs	$2,762,000
Net Benefits	$1,806,000
Benefit/Cost Ratio	1.7

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1.0 Introduction

1.1. - Project Purpose

The Richmond Harbor channel does not and will not efficiently accommodate modern and future bulk carriers. The recommended plan for the Richmond Harbor Navigation Improvement Project would: (1) reduce the potential for vessel collisions and grounding, (2) permit efficient vessel operations and reduce tidal delays, and (3) provide economies-of-scale benefits for waterborne commerce. Furthermore, the recommended plan will provide a safe, channel of sufficient width and depth for modern vessel movement within the Port of Richmond by improving the channel configuration and providing a new turning basin.

1.2. - Project Location

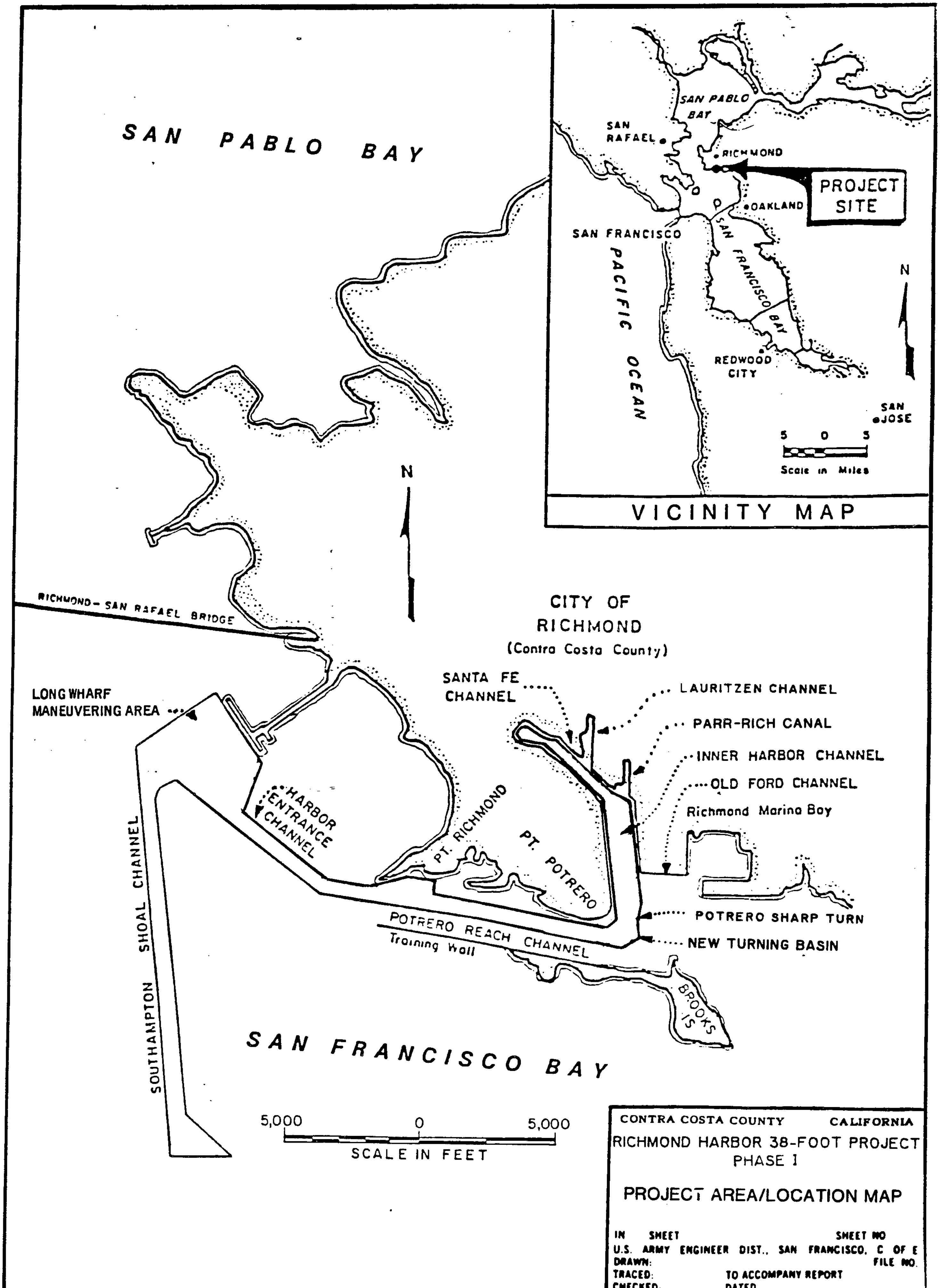
Richmond Harbor is located in Contra Costa County, California, on the eastern shore of central San Francisco Bay, about 6 miles northwest of the eastern entrance to the Bay Bridge. The Harbor area consists of the Harbor Entrance Channel, Potrero Reach Channel, Potrero Sharp Turn, Inner Harbor Channel, and Santa Fe Channel. As shown on Figure 1, the project begins at the end of the Richmond Long Wharf Maneuvering Area and extends four nautical miles from the Harbor Entrance Channel to the Santa Fe Channel (600 feet northwest, beyond the Lauritzen Channel).

1.3. - Pertinent Background Information

Development of Richmond Harbor began at the turn of the century. At the Port's height during World War II, Richmond was the national center for shipbuilding, with a liberty ship being launched almost daily. Existing improvements include a channel originating in the natural deep-water of the Central Bay and extending through the Southhampton Shoal Channel and the Maneuvering Area which were deepened from -35 feet to -45 feet MLLW in 1986 as part of the John F. Baldwin navigation project. The existing channel from the Richmond Entrance Channel to the mouth of the Santa Fe Channel is maintained at a project depth of -35 feet MLLW. The shore and channel between Point Richmond and Point Potrero are protected by a rock training wall extending 10,000 feet in a westerly direction from Brooks Island.

Recognizing the growth of waterborne commerce and the use of larger vessels, the Committee on Public Works of the House of Representatives adopted a resolution on July 10, 1968 authorizing a study to determine the feasibility of improving navigation conditions at the Richmond Harbor.

A feasibility study by the San Francisco District titled, Richmond Harbor California, Deep-Draft Navigation Improvements Feasibility and Environmental Impact Statement - September 1981, recommended modification of the project. The study proposed a variable width channel at -41 feet MLLW and a new turning basin with a diameter of 1,425 feet at the Old Ford Channel.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SAN PABLO BAY
SAN RAFAEL
RICHMOND
PROJECT SITE
OAKLAND
SAN FRANCISCO
PACIFIC OCEAN
SAN FRANCISCO BAY
REDWOOD CITY
SAN JOSE
N
5 0 5
Scale in Miles
VICINITY MAP
N
RICHMOND - SAN RAFAEL BRIDGE
CITY OF RICHMOND
(Contra Costa County)
LONG WHARF MANEUVERING AREA
SANTA FE CHANNEL
LAURITZEN CHANNEL
PARR-RICH CANAL
INNER HARBOR CHANNEL
OLD FORD CHANNEL
Richmond Marina Bay
HARBOR ENTRANCE CHANNEL
PT. RICHMOND
PT. POTRERO
POTRERO SHARP TURN
NEW TURNING BASIN
POTRERO REACH CHANNEL
Training Wall
BROOKS IS
SOUTHAMPTON SHOAL CHANNEL
SAN FRANCISCO BAY
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SCALE IN FEET
CONTRA COSTA COUNTY CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT
PHASE I
PROJECT AREA/LOCATION MAP
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FIGURE 1

The feasibility report was submitted to the (then) Board of Engineers for Rivers and Harbors (BERH), and in a report dated April 5, 1982, the BERH concurred, in general, with the recommended plan except that a minimum channel width of 600 feet was recommended, as advised by the California Inland Pilots Association.

BERH submitted the report to Headquarters, U.S. Army Corps of Engineers (HQUSACE) then called the Office of the Chief of Engineers, OCE. After review, OCE forwarded it to the Water Resources Council (WRC). Upon deliberation of the Council, the report was returned to HQUSACE, and forwarded to the Office of Management and Budget (OMB). A supplemental analysis of the Feasibility Report was conducted in October at the request of HQUSACE to test the operating assumptions of the without project condition. The study reaffirmed the economic justification of the project (HQUSACE 1987).

A Plan-of-Action (POA) was prepared in accordance with Engineering Regulation (ER) 1110-2-1150 upon receipt of funds for continuation of Planning and Engineering, later converted to Post Construction Engineering and Design (PED). The plan presented the time and cost requirements to arrive at a design of sufficient detail to proceed with the plans and specifications for construction. The POA was presented at a General Design conference held July 18, 1985 and approved by the South Pacific Division (SPD) January 10, 1986 (HQUSACE 1987).

In September 1987, a draft of the General Design Memorandum (GDM) for Phase I was completed and submitted to the South Pacific Division (SPD) for review. Due to complications with the Super Fund project in the Lauritzen Channel, the project was delayed and redesigned.

1.4. - Prior Reports

This project has been the subject of intensive environmental and engineering investigations from the feasibility phase through to the present. The Corps and Port of Richmond (local sponsor) have prepared numerous reports and supporting documents regarding the Richmond Harbor Navigation project. The reports prepared to date include, but are not limited to the documents listed below:

Richmond Harbor Ship Simulation Studies - September 1995. The Corps' Waterways Experiment Station (WES) conducted simulation studies to assist in the design of channel reaches and the turning basin. This document is the culmination of four studies, the first started in 1985 and the last completed in October 1994.

Richmond Harbor Deepening Eelgrass Survey Final Report - November 1994. This report determined the presence, distribution, and abundance of eelgrass *Zostera marina* in areas affected by the deepening and widening of the channel and the turning basin.

Evaluation of Upland Disposal of Richmond Harbor, California, Sediments from Santa Fe Channel - July 1993. This report presents data from several elutriate and leach tests on sediments from the Santa Fe Channel. Analysis of the sediment data indicates a low potential

for adverse environmental effects from upland disposal.

Richmond Harbor Deepening Project - Final Environmental Working Paper - June 1992. This report was intended to provide background information and preliminary evaluation of alternatives to assist in determining the array of disposal sites to be analyzed in the Supplemental Environmental Impact Statement (SEIS) that will be prepared for the Richmond Harbor project.

Long-Term Management Strategy (LTMS) for Dredged Material Disposal in the San Francisco Bay Region - August 1990. This report documented the public (federal and non-federal) concerns (water quality, toxicity, long-term effects, bioaccumulation and dredged material placement) pertaining to dredged material disposal within the San Francisco Bay for all navigation improvement projects (Oakland, Richmond, John F. Baldwin)

Richmond Harbor Deep-Draft Navigation Improvements, General Design Memorandum Phase I (Draft) and Supplement to the Environmental Impact Statement - September 1987. This document recommends a variable channel width at -38 feet MLLW and a new, 1,200-foot-diameter turning basin at the Old Ford Channel.

Richmond Harbor California, Deep-Draft Navigation Improvements Feasibility and Environmental Impact Statement - September 1981. This document recommends a variable channel width at -41 feet MLLW and a new, 1,425-foot diameter turning basin at the Old Ford Channel.

Final EIS for the Richmond Deep-Draft Navigation Improvements -1981. This data report summarized the environmental effects associated with the channel improvements. Initially, the Alcatraz disposal site was selected for the disposal of the Richmond dredged material. However, due to new volume restrictions imposed by the California Regional Water Quality Control Board (RWQCB), as well as the Bay Conservation Development Committee (BCDC) constraints on bay bottom filling at Alcatraz and other in-Bay disposal sites, the EPA Ocean disposal site was selected.

Transportation Plan Study - March 1977. The major highway access for trucks, trailers and the movement of container unit, and the railroad marshaling yard was studied by Bechtel, Inc. and Leon Rimov & Associates in March 1977. In the study report, the rail terminal facility and highway access are discussed in detail.

Impact of Increased Boat Traffic in Point Potrero Reach Study - May 1976. The impact study was conducted by Koebig, Inc. and was completed in May 1976. This study focuses on the impact of additional small-craft traffic in the existing Richmond Inner Harbor Channel.

South Richmond Shoreline Special Area Plan - November 1975. In November 1975, the San Francisco Bay Conservation and Development Commission (BCDC) approved the formulation of a citizens committee (11 Richmond and four BCDC representatives) to coordinate and achieve compatibility between BCDC's Bay Plan and Richmond's General Plan by developing a Special Area Plan.

Richmond Marina Feasibility Study - October 1975. A Richmond Marina feasibility study in the Inner Harbor Basin was conducted by Koebig, Inc. for the City of Richmond and completed in October 1975. Study findings indicate that the proposed Richmond Marina is feasible from an engineering and economic standpoint. Phase I of this marina project is completed.

Environmental Impact Report for the Master Plan - May 1975. In accordance with the California Environmental Quality Act, the Richmond Redevelopment Agency and the City of Richmond Planning Department hired Torrey & Torrey, Inc. to conduct and prepare the EIR for the Master Plan. A draft EIR for the Master Plan was distributed to the public for comments, and a public hearing for the draft EIR was held in December 1974. The final EIR for the Master Plan was certified by the City of Richmond in May 1975.

Port Area and Marina Master Plan Study - January 1974. The Port Area and Marine Master Plan Study was begun in June 1973 with a grant from the U.S. Department of Housing and Urban Development (also under Section 301a, Housing Act of 1954, P.L. 89-136. as amended). The study was conducted by Bechtel, Inc. and Leon Rimov & Associates, and was completed in January 1974.

Richmond Coastline Plan Study - January 1973. The Richmond Coastline Plan study was begun in July 1971 with a comprehensive Planning Assistance Grant from the U.S. Department of Housing and Urban Development (HUD) (under Section 301a, Housing Act of 1954, P.L. 89-136, as amended). The Mayor's Waterfront Development Committee completed the study in January 1973 and the plan was adopted by the City Council on 12 March 1973.

Port Development Feasibility Study - August 1972. A preliminary economic feasibility study of Port of Richmond development began in March 1971 and was conducted by Bechtel, Inc. for the Economic Development Administration, U.S. Department of Commerce. The Bechtel study was completed in August 1972.

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2.0 Project Authorization and Recommended Plan

2.1. - Project Authorization

The Water Resources Development Act of 1986 (WRDA 86), Pubic Law 99-662, Section 202 authorized construction of the navigation channel improvements to the Richmond Harbor reads:

"The project for navigation Richmond Harbor, California: Report of the Chief of Engineers, dated August 8, 1982, at a total cost of $43,800,000 with an estimated first Federal cost of $26,500,000 and an estimated first non-Federal cost of $17,300,000."

Since authorization, the Richmond Harbor project has been separated into two phases. Phase I consists of a 38-foot project with an improved turning basin, while Phase II, consisting of a 41-foot project, has been delayed indefinitely.

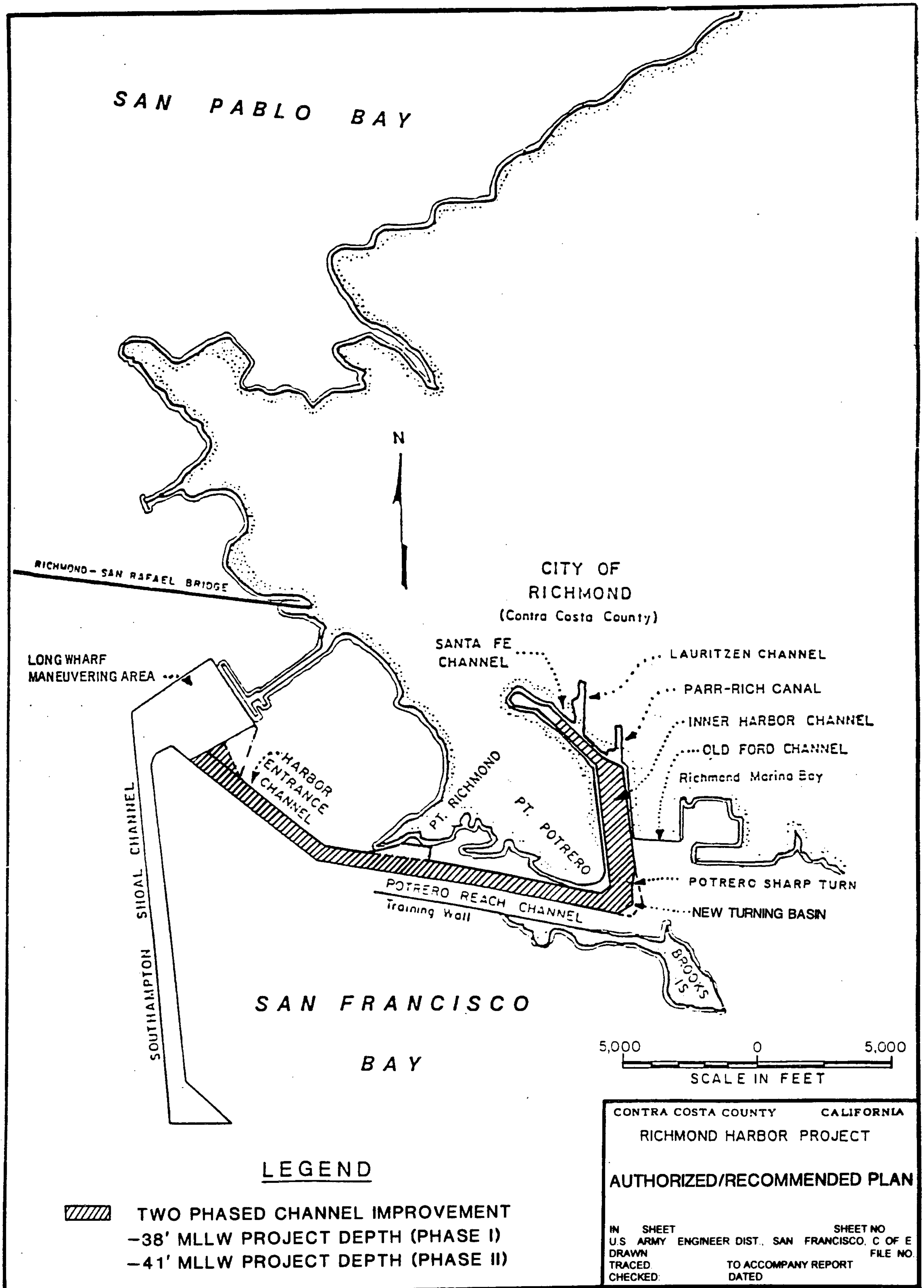
2.2. - Authorized Plan

Based on the above authorization, the plan of improvement for Richmond Harbor in 1986 called for the widening and deepening of the existing 4.0-nautical-mile Richmond Harbor Channel from -35 feet to -41 feet MLLW.

2.3. - Recommended Plan

In response to the growth of bulk cargo movements in the Port of Richmond and the local sponsor's request that measures be undertaken to reduce the initial non-Federal cost, a two-stage construction plan was formulated. Phase I, the recommended plan of improvement presented herein, calls for: (1) deepening the existing navigation channel from -35 feet to -38 feet MLLW; (2) providing a 1,260-foot diameter turning basin at Point Potrero; and (3) disposing of approximately 1.91 million cubic yards (MCY) of material (see Figure 2). About 1.68 MCY will be dredged from the Federal channel and disposed of at an off-shore site 51 nautical miles from the Golden Gate Bridge. The remainder of the material (234,000 CY) will be used as fill in the parking lot at the Point Potrero Marine Terminal. Annual project maintenance will require the dredging and disposal of approximately 435,000 CY of material at the Alcatraz in-Bay disposal site.

From the project limit beginning at the downstream end of the Richmond Harbor project area—at the harbor entrance channel—to Point Potrero, the channel bottom width varies from less than 500 feet to 600 feet. The new 1,260-foot-diameter turning basin is located adjacent to Point Potrero. The channel bottom width narrows from approximately 860 feet to 740 feet from Point Potrero to the entrance of the Santa Fe Channel. The channel bottom width narrows again to 200 feet and the project area ends at the upstream limit, 600 feet northwest of the Lauritzen Channel. Throughout the project area, the channel side slope is one vertical to three horizontal (1V:3H).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OLD FORD CHANNEL
Richmond Marina Bay
LONG WHARF
MANEUVERING AREA
HARBOR
ENTRANCE
CHANNEL
PT. RICHMOND
PT. POTRERO
POTRERO SHARP TURN
NEW TURNING BASIN
POTRERO REACH CHANNEL
Training Wall
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SOUTHAMPTON SHOAL CHANNEL
SAN FRANCISCO
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SCALE IN FEET
LEGEND
TWO PHASED CHANNEL IMPROVEMENT
–38' MLLW PROJECT DEPTH (PHASE I)
–41' MLLW PROJECT DEPTH (PHASE II)
CONTRA COSTA COUNTY
CALIFORNIA
RICHMOND HARBOR PROJECT
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FIGURE 2

2.3.1. - General Navigation Features

For the Richmond Harbor, the recommended plan of improvement calls for deepening the harbor from -35 feet to -38 feet MLLW, and widening the Entrance channel from 500 feet to 600 feet, creating a new 1,260-foot-diameter turning basin, and narrowing the Santa Fe channel by 25 feet on each side to provide for adequate berthing areas.

2.3.2. - Dredged Material Disposal Plan

Approximately 1.91 MCY of material will be dredged from the Richmond Harbor. The material to be dredged has been classified subsequent to extensive sediment, chemical, physical, biological, and toxic testing to determine the material's suitability for disposal at several proposed sites. The types of sites considered include: ocean, aquatic, and upland disposal. A comparison of criteria indicates that there is material which may be suitable for more than one disposal site. The development of the dredging sequence is discussed in Section 4 of this document.

The Recommended Plan is to dredge the Richmond Harbor and dispose of the material at the designated Environmental Protection Agency (EPA), Region IX ocean disposal site and at the parking lot next to the Point Potrero Marine Terminal.

Approximately 1.75 MCY of sediment has been determined to be suitable for ocean disposal. The EPA is setting an interim site capacity for the SF-DODS (San Francisco dredge ocean disposal site) of 6 MCY of dredged material per year, which will be in effect only until December 31, 1996. The EPA's site designation decision reflects efforts for designating and identifying sites for long-term disposal use.

Approximately 234,000 CY of material have been determined to be unsuitable for unconfined aquatic disposal. This material will be used as fill for the parking lot disposal area.

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3.0 Design Basis

3.1. - Geology

Richmond Harbor lies on the northern side of San Francisco Bay in a natural depression low-lying plain bordering the eastern shore of San Francisco Bay. Recent sediments deposited in the Bay consist of very soft to soft silty clays and lenses of loose to medium dense silty and clayey sands, commonly referred to as Younger Bay Mud (YBM) or just Bay Mud. The Younger Bay Mud ranges in thickness from a few feet along the shoreline to greater than 60 feet in the Entrance Harbor channel and at the Potrero Sharp Turn area. The Younger Bay Mud has been undergoing deposition in the Bay since 6,000 to 8,000 years before the present. Underlying the YBM are brown, firm to stiff clays probably related to the alluvial fan deposits immediately to the east and deposited in late Pleistocene, probably during the lower sea level stand that occurred as a result of the ice sheet advance during the Wisconsin glacial period. Beneath the brown alluvial clays is the upper portion of the Older Bay Mud (OBM), bluish gray to a greenish-gray firm to very stiff clay, perhaps equivalent to the marine clays of the San Antonio formation and may have been deposited during the Sangamon interglacial period 70,000 - 100,000 years ago.

3.2. - Soils

Subsurface soils explorations were performed to classify the soils within the project area. Subsurface explorations and boring samples at 41 locations have been performed to classify the soils within the Richmond Harbor project area. In addition, field classifications were logged at the time of sampling. The consistency of each soil sample was determined and recorded on field boring logs. The soils encountered were: (1) dark gray, silty clay; (2) loose to medium silty and clayey sands of YBM; (3) brown, firm to stiff, clays; (4) minor lenses of brown, medium dense, clayey to silty sands; and (5) firm to very stiff bluish-gray to greenish-gray, silty clay.

3.3. - Seismicity

Richmond Harbor lies on the northeastern side of San Francisco Bay within the seismically active San Andreas fault zone and its related faults. The San Andreas lies 13.5 to 14.5 miles to the west, and the Hayward fault lies 3.5 to 4.5 miles to the east. Both faults are right lateral strike-slip faults and trend in a north/northwest direction. Because of the low strength of the Bay Mud and comparably steep cut slopes in the existing harbor area, it is assumed that local slope failure will occur during a moderate to strong earthquake generated from these fault lines. The San Andreas fault has been assigned probabilities for earthquake magnitudes (M) equal to or exceeding a M7 for specific segments of the fault. The fault was divided into segments in 1990 by the Working Group on California Earthquake Probabilities (U.S.G.S., Circular 1053, 1990). Those segments near and within the San Francisco Bay area that have probabilities of producing an earthquake of M7 or greater are as follows: San Francisco Peninsula Segment, 23% chance of a M7 within the next 30 years; and the North Coast Segment, 2% chance of $M \geq 8$ in the next 30 years. It is noted that in 1988, the Working

Group had predicted a 30% chance of M7 event within the next 30 years for the Santa Cruz Mountains Segment. The southern portion of this segment produced a M7.1 earthquake in October 1989. The northern portion of this segment has been assigned an 18% chance of a $M \geq 6.5$ within the next 30 years by the Working Group in 1990. This same Working Group on California Earthquake probabilities has also segmented the Hayward fault into the Northern East Bay Segment and the Southern East Bay Segment. Each of these segments have been assigned a probability greater than 20% for a M7 earthquake in the next 30 years. The Southern East Bay Segment has a 23% probability; the Northern East Bay Segment, a 28% probability. Should both segments rupture simultaneously, the resulting seismic event could be as great as a M7.5 earthquake.

Richmond Harbor will be subject to the effects of earthquakes occurring on either fault on either segment. It is assumed that local slope failures will occur during moderate to strong earthquakes due to the low shear strength of the Bay Mud and the low horizontal seismic load necessary to reduce the factor of safety for the design slope to less than 1.1.

Furthermore, the parking lot disposal site's geotechnical integrity has been reviewed and deemed adequate. A major seismic event would cause slumping at the center of parking lot; therefore, it is projected that no material would return to the Bay.

3.4. - Bedrock

Bedrock has been removed from two areas inside the channel at Point Potrero. Bedrock in the area was explored with five rock core borings and seven wash-boring probes. Bedrock is found at an elevation of -36.5 feet MLLW at boring IF 86-1 and at elevation -37.6 feet MLLW at boring IF 86-4. Bedrock is closely to very closely fractured, highly weathered graywacke sandstone that has been stained brown by the oxidation of iron bearing minerals. The sandstone, due to the close fracturing and high degree of weathering, is relatively weak and is considered to be easily ripped. Interbeds of highly weathered shale were also indicated by the rock coring The shale is very closely fractured and will also be easy to excavate. The bedrock can be easily excavated by a dipper bucket equipped with rock teeth or by a rotary cutting head suitably-equipped with rock-cutting teeth. See Appendix A for the Geotechnical boring logs.

3.5. - Slope Stability

The generally used 1 vertical to 3 horizontal (1V:3H) side slopes used for in-Bay dredging projects were analyzed for this project using the Corps of Engineers UTEXAS 2 slope stability program, a modified Bishop's arc method, on a personal computer. The most critical side slopes are those to be constructed in the Turning Basin. The top-of-slope elevation in the Turning Basin approaches -4 feet MLLW. The slopes were analyzed for a 36-foot cut in a layer of Younger Bay Mud approximately 60-feet thick. It was found that 1V:3H slopes have a static factor of safety of at least 1.5. Moreover, with a seismic coefficient of 0.05, the factor of safety was 1.03. The 1V:3H slope was also analyzed for a 35-foot cut in a layer of 38-foot thick Bay Mud underlain by stiff clay. The factor of safety was found to be slightly higher for both the static and pseudostatic seismic coefficient loads condition. A seismic

coefficient of 0.05 had a factor of safety of 1.07.

It is recommended that for Phase I, all slopes excavated in the soft Younger Bay Mud be no steeper than 1V:3H for simplicity of construction, even though slopes of lesser heights will yield higher factors of safety. Also, it should be noted that the recommended side slopes will provide only minor seismic stability for the higher slopes, and failures can be expected for moderate or stronger seismic events close to the project.

3.6.- Groundwater

It is highly probable that in some areas salt water intrusion landward into the bedrock and sediments has already taken place. This is evidenced by the exposure of the bedrock at Point Potrero and the perimeter of Brooks Island, and by the existence of minor sand lenses between 0.0 MLLW and -35 feet MLLW that obviously have been transected during historic harbor construction. The bedrock was exposed during the construction of dry dock facilities at Point Potrero and again during the mid-1950's when high areas of bedrock along the inside edge of the channel in the wide-turn area were removed to -37 feet MLLW. Borings by others along the channel of Richmond Harbor indicate that minor sand lenses in the Brown clays and Younger Bay Mud occur between 0.0 MLLW and -35 feet MLLW. The sand lenses project to the very edge of the channel. Although it is not known if the sand lenses are connected to any specific fresh water aquifer, it can be assumed that these lenses have been contaminated by salt water.

As indicated by the boring logs, a few sand lenses will be intersected during Phase I deepening. The brown clayey sand later of boring RI 86-9 will be intersected by the channel deepening but it does not appear to have any significant horizontal extent. A 3-foot thick lens of greenish gray silty sand with the Older Bay Mud occurs at approximately -45.5 feet MLLW in a boring by others near the southern end of Terminal 3. Since the sand layer in RT 86-9 appears to be a remnant of probable brown clayey alluvial deposits it cannot be correlated with a sand layer deposited in an older formation. The sand lenses in the Younger Bay Mud that may be excavated during the dredging of the turning basin appear to have limited horizontal extent. The sand layers at borings TB-2, RI 86-8, TB-3, and TC-7 do not show in boring TB-4, and do not appear to be connected with the thin clayey sand layers in TC-1, TB-7, TC-2, and TC-3 which are higher in elevation and probably more recent in age. The sand lens being a geologically recent deposition in a marine environment and of probable limited extent are unlikely sources of fresh water.

It is concluded, based on the borings as shown on the boring location map in Appendix A, that no major ground water aquifers will be intersected or directly exposed to salt water intrusion by Phase I deepening.

3.7. - Cross Winds and Currents

The maneuverability of vessels in a navigation channel is affected by extreme currents and winds. The magnitude and direction of these forces determines the design of the channel. When forces are parallel to the vessel's motion, the momentum of the vessel will be increased

or decreased, depending on the direction of the forces relative to the vessel. In this case, the length of the navigation channel and distance required to stop a vessel are crucial. If, on the other hand, the forces are perpendicular to the vessel's motion, the vessel will tend to move laterally; therefore, the channel width becomes significant.

In the Richmond Harbor, vessels must enter the channel on the up-current side to avoid being grounded on the down-current bank of the channel. The currents run diagonally across the Entrance Channel, often causing ships to be piloted at a "crab angle" to stay within the maintained channel. In the Potrero Reach, ebb and flood tide flows were assumed to be channeled by the training wall, but results from the San Francisco Bay Model indicate complex surface and bottom currents. Recent data were used in the navigation simulation study conducted by the Waterways Experiment Station (WES) at Vicksburg. In the Potrero Sharp Turn, ships change direction 110 degrees and are "set" east during ebb tide and west during flood tide. Currents are negligible in the new turning basin and the Inner Harbor Channel.

Winds also exert an external force on vessel operating in the channel and tend to set a ship in the downwind direction. Winds at Richmond Harbor are predominantly from the west-southwest through west-northwest. Ballasted auto-carriers provide a large "sail" area and are very difficult to maneuver on windy days on outbound runs, especially at the Potrero Sharp Turn.

3.8. - Physical Constraints

There are no physical constraints to the widening of the Entrance Channel or the new turning basin. However, wharves, piers, and the Richmond Training Wall limit channel widening in the Potrero Reach and Inner Harbor Channel. Phase I of construction is designed for modern bulk carriers.

3.9. - Navigation Requirements

The existing Richmond Harbor Channel contains sharp turns where it is increasingly difficult to maneuver against strong winds, waves, and currents, especially when it is foggy. Factors causing hazardous navigation conditions are shown on Figure 3. Ships entering the harbor must transit the 45-foot-deep Southampton Shoal Channel and Richmond Long Wharf Maneuvering Area as they exit San Francisco Bay (this involves a 140 degree starboard turn to align the vessel with the Entrance Channel). Usually, two tug boats come alongside inbound ships to aid their transit and dockage (see Figure 4 for Bulk Terminal locations).

Inbound ships must turn 34 degrees to port at the bend in the Entrance Channel to align the vessel with the Potrero Reach. In the past, representatives for the San Francisco Bar Pilots suggested that a navigation simulation study be conducted to determine if the turn should be widened.

Although the training wall provides protection from cross-currents in the Potrero Reach, ships traveling this part of the channel are subject to strong cross-winds. Ships most affected by

cross-winds are ballasted car carriers, which have very large "sail areas."

At the Potrero Sharp Turn, inbound ships turn 110 degrees to port. When surface currents combine with a reversing tide, vessels are subject to a counterclockwise eddy, and control is difficult. To negotiate this turn, ships must slow significantly which makes them vulnerable to east-west currents aligned with Potrero Reach which are strongest during ebb tide. Two rock outcroppings adjacent to Point Potrero and the very shallow water (-4 feet MLLW) east of the turn make it more difficult for ships to successfully maneuver through this turn.

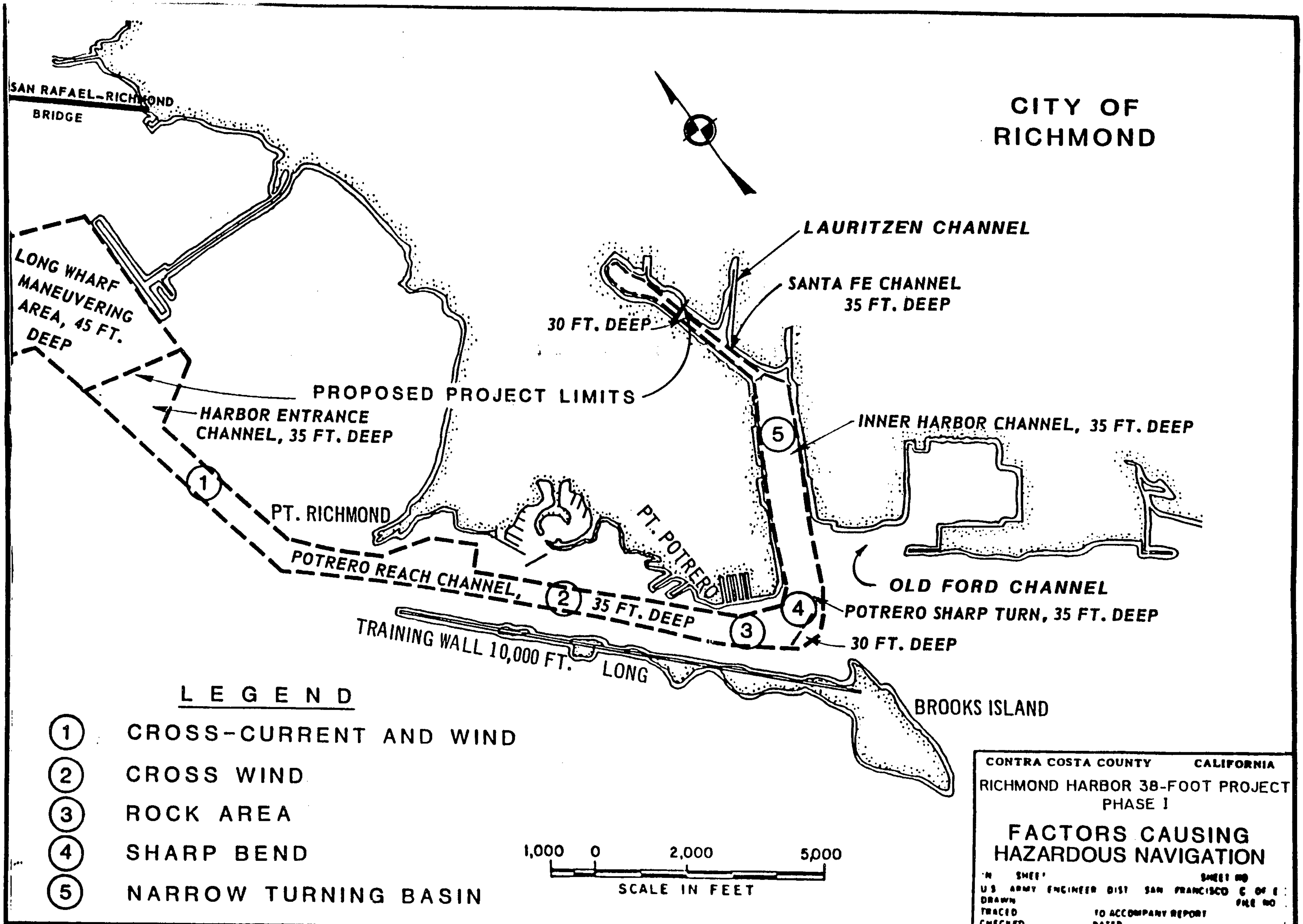
CITY OF RICHMOND
SAN RAFAEL-RICHMOND BRIDGE
LONG WHARF MANEUVERING AREA, 45 FT. DEEP
PROPOSED PROJECT LIMITS
HARBOR ENTRANCE CHANNEL, 35 FT. DEEP
PT. RICHMOND
POTRERO REACH CHANNEL, 35 FT. DEEP
PT. POTRERO
TRAINING WALL 10,000 FT. LONG
LAURITZEN CHANNEL
SANTA FE CHANNEL 35 FT. DEEP
30 FT. DEEP
INNER HARBOR CHANNEL, 35 FT. DEEP
OLD FORD CHANNEL
POTRERO SHARP TURN, 35 FT. DEEP
30 FT. DEEP
BROOKS ISLAND
LEGEND
1 CROSS-CURRENT AND WIND
2 CROSS WIND
3 ROCK AREA
4 SHARP BEND
5 NARROW TURNING BASIN
1,000 0 2,000 5,000
SCALE IN FEET
CONTRA COSTA COUNTY CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT
PHASE I
FACTORS CAUSING HAZARDOUS NAVIGATION
U.S. ARMY ENGINEER DIST. SAN FRANCISCO
TO ACCOMPANY REPORT

FIGURE 3

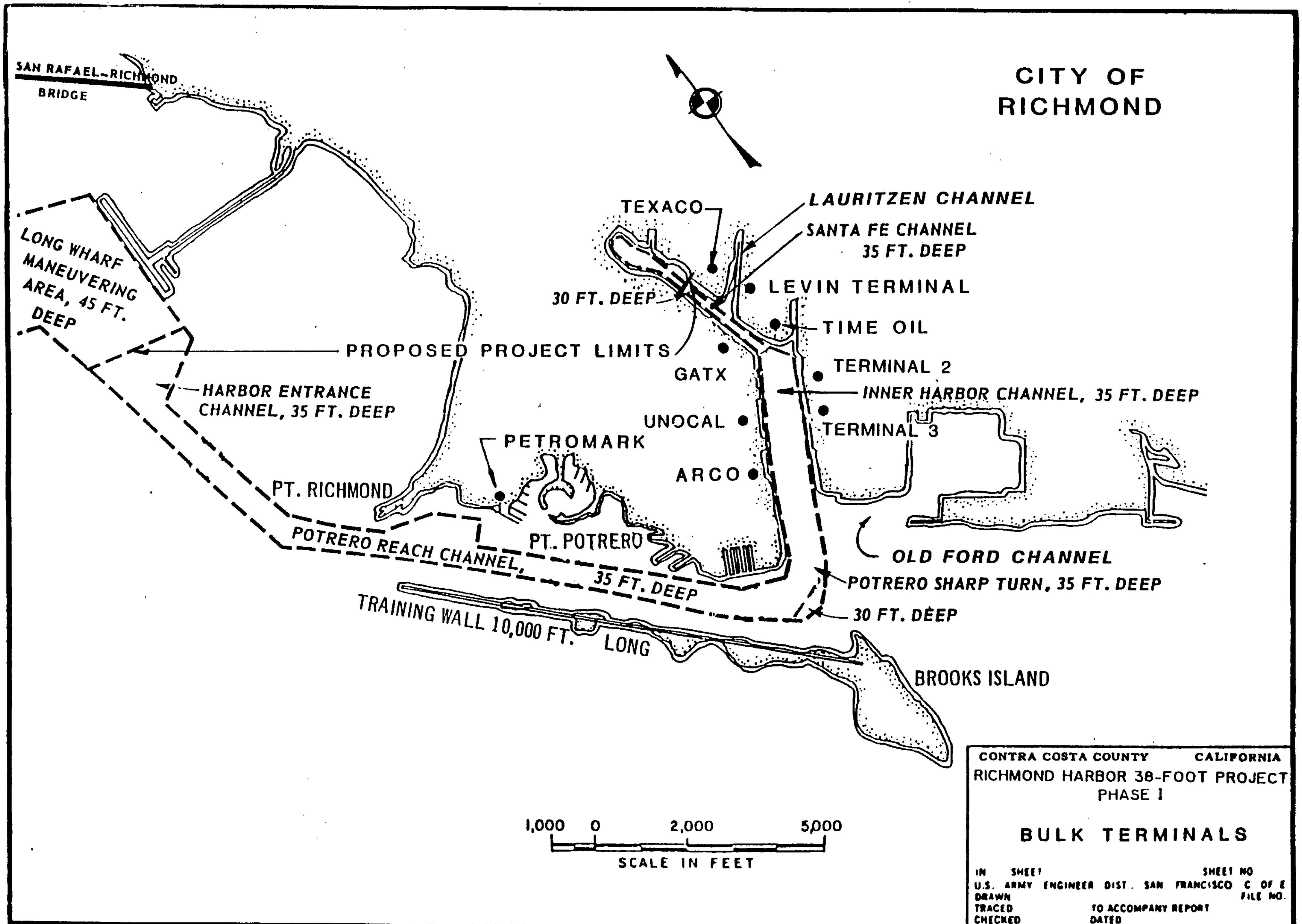
CITY OF
RICHMOND
SAN RAFAEL–RICHMOND
BRIDGE
LONG WHARF
MANEUVERING
AREA, 45 FT.
DEEP
HARBOR ENTRANCE
CHANNEL, 35 FT. DEEP
PROPOSED PROJECT LIMITS
TEXACO
LAURITZEN CHANNEL
SANTA FE CHANNEL
35 FT. DEEP
LEVIN TERMINAL
30 FT. DEEP
TIME OIL
GATX
TERMINAL 2
INNER HARBOR CHANNEL, 35 FT. DEEP
UNOCAL
TERMINAL 3
PETROMARK
ARCO
PT. RICHMOND
PT. POTRERO
OLD FORD CHANNEL
POTRERO REACH CHANNEL,
35 FT. DEEP
POTRERO SHARP TURN, 35 FT. DEEP
30 FT. DEEP
TRAINING WALL 10,000 FT. LONG
BROOKS ISLAND
1,000 0 2,000 5,000
SCALE IN FEET
CONTRA COSTA COUNTY CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT
PHASE I
BULK TERMINALS
IN SHEET SHEET NO
U.S. ARMY ENGINEER DIST. SAN FRANCISCO C. OF E
DRAWN FILE NO.
TRACED TO ACCOMPANY REPORT
CHECKED DATED

FIGURE 4

Presently, ships enter upstream of Point Potrero turn in the Inner Harbor Channel which has a maximum width of 850 feet with 75-foot-wide berths on each side (1,000-foot width between Pierhead and Bulkhead Lines). Large ships occasionally encroach into berthing areas during turns. The present Corps of Engineers guidelines require 125-foot-wide berths. If the berths are widened per guidelines, the Inner Harbor channel will constrict by 50 feet on each side resulting in a 750-foot width. As a result, this area will not be usable for turning large ships. No simulation study was proposed for this protected channel.

3.10. - <u>One-Way Design Considerations</u>

The proposed channel configuration is designed for one-way traffic. Pilots in San Francisco Bay are in agreement that a two-way channel is neither practical nor necessary for the present and future vessel traffic in Richmond Harbor. Data collected by the Port of Richmond indicate that in 1986 a total of 424 ships made inbound and outbound trips in the Harbor (excluding the Chevron Long Wharf). With the average number of larger vessel calls at about two per day, the probability of significant delays is small and ship traffic congestion would be minimal. The pilots regard the existing one-way operating procedure, in which smaller vessels give way to larger vessels, as adequate. Under this arrangement, one-way traffic operations could cause occasional delays of 10 to 15 minutes if two ships approached the channel simultaneously from opposite directions. In the Inner Harbor, existing piers, wharves, and rip-rapped banks impose constraints to two-way navigation at many locations. As a result, the Corps concluded that a one-way traffic channel is adequate for the proposed navigation improvement and a two-way traffic channel is unjustified.

3.11. - <u>WES Model Simulation Study</u>

The Waterways Experiment Station Hydraulics Laboratory (WES) of the Corps of Engineers performed a navigation simulation study to verify the feasibility of relocating the turning basin and optimizing its size. In addition, previous simulations conducted for the 1987 DGDM were updated and revalidated. The study purpose was to ensure that minimum turning basin dimensions were consistent with safety.

The San Francisco Bay Mathematical model was used to develop tidal current patterns in three test turning basins located near the Potrero Sharp Turn. Two professional pilots from the San Francisco Bar Pilots assisted in testing by piloting the simulated ship in the study area. The results showed that the existing turning basin was inadequate due to very slow and inefficient ship turning operations.

WES determined that all three turning basin plans are acceptable and recommended a design between alternatives one and two that included modifications to the present navigation aids as suggested by the pilots. The San Francisco Bar Pilots endorsed the WES recommended turning basin in a letter. They said the turning basin would "make [the turn] safer and more efficient in the maneuvering of larger vessels." (See Appendix B for the simulation study.)

3.11.1 - Design Vessel Characteristics

WES determined design vessel dimensions by examining the drafts of current and future ships currently transiting the project reaches. Specifically, WES studied three project reaches —the previously mentioned Turning Basin (Potrero Sharp Turn), Harbor Entrance Channel, and the Santa Fe Channel—in three separate reports. At the project depth analyzed, the largest vessel expected to use that reach of the channel—based on the economic efficiency of the various vessel sizes—was used as the design vessel. Table 1 summarizes the Design Vessel Characteristics for each reach analyzed. Dimensions denoted with an asterisk are based on data from the Economic Guidance Memorandum, 95-2, Deep Draft Vessel Cost Estimates. Otherwise, vessel dimensions were developed by WES.

Table 1
Design Vessel Characteristics

Characteristic	*Entrance Channel*	*Turning Basin*	*Santa Fe Channel*
Vessel Type	Containerships	Bulk Carrier	Bulk Carrier
Vessel Size, DWT	41,000*-163,000*	80,000	66,000*
Beam, FT	97*-152*	106	105
Length, overall; FT	638-950	855	738
Fully-loaded draft, FT	37-57*	46*	42

*Derived using Economic Guidance Memorandum 95-2, Deep Draft Vessel Cost Estimates, Appendix A

3.12. - Channel Configuration

The design width for safe navigation is based on factors including vessel size and maneuverability, traffic conditions, winds, waves, currents, bottom and bank conditions, visibility, mode of operation, and ship turning basin requirements. Conditions vary throughout the length of Phase I; therefore, project channel conditions are addressed by reaches proceeding upstream. For the recommended plan, see Plates 1-5. (Project plans and specifications will be completed in metric units according to HQUSACE guidance.)

3.12.1. - Entrance Channel

This 1.3-mile-long channel provides ingress and egress for ships operating between the Inner Harbor and the Long Wharf Maneuvering Area (and from there to San Francisco Bay). Based on WES simulation studies, the mouth of the Entrance Channel will be widened to 1,020 feet. From there, the channel remains unconfined and 600-feet wide. At the 35-degree bend on the north side of its upstream end, the channel—per the wishes of the San Francisco Bar Pilots—will be widened to 800 feet. In addition, per Coast Guard approval, Green Buoy 5 and Red Buoy 6 will be moved outside the confines of the channel for safety. This entire reach is subject to strong currents and cross-winds, and to seasonal fog and low visibility.

3.12.2. - Potrero Reach Channel

This 1.5-mile-long channel provides access to the Inner Harbor from the Entrance Harbor Channel junction. The Potrero Reach Channel accesses Terminal 1, leased and operated by Petromark, Inc. located to the northeast upon entering the channel. A turning basin that will not be deepened is also at this location (adjacent to Point Richmond). The Potrero Reach Channel is protected to the south from cross-currents by Brooks Island and a 10,000-foot training wall. The existing channel is adversely affected by shoaling on both sides and constrained maneuverability due to the short turning radius entering the Potrero Sharp Turn. The proposed channel width, which is the same as the existing channel, varies from 510 feet at the confluence with the Entrance Channel to 480 feet midway to 590 feet at the Potrero Sharp Turn.

3.12.3. - Potrero Sharp Turn

The next 0.6-mile section includes both the Potrero Sharp Turn and the new turning basin. The channel configuration for this reach will be changed—based on WES simulation studies—to reduce the likelihood of vessels grounding as they navigate the sharp turn. The turning basin design involves widening the channel from 0 to 400 feet and includes a 1,260-foot-diameter circle to enable ships to turn safely with tug assistance. Variable current and wind conditions in this area require good pilotage and close tug control during the ship turning operation, particularly with a 855-foot, design-sized ship.

3.12.4. - Inner Harbor Channel

The Inner Harbor is a confined channel extending 0.7 miles beyond the turning basin to the confluence of the Port Richmond Channel between rows of existing wharves serving bulk operations. The existing channel will be narrowed 25 feet on each side—to between 860 feet to 720 feet—to widen existing berthing areas. In addition, the Port and the San Francisco Bar Pilots have requested the removal of dolphin moorings and piles in the GATX berthing area to improve navigation and safety. The Port is resolving this issue at the local level.

3.12.5. - Santa Fe Channel

The Santa Fe Channel is a confined channel extending 0.4 miles beyond the Inner Harbor Channel. The channel will remain 200 feet wide between berths. Ship speeds in this channel are very low; therefore, ship dynamics do not have a major effect on ship maneuvering and control. The project ends 600 feet northwest of the Lauritzen Channel, where the existing channel depth decreases from 35 to 30 feet.

3.13. - <u>Channel Depth</u>

The project depth of -38 feet MLLW is based on the underkeel clearance requirements of observed bulk vessels using Richmond Harbor. It is not economical to improve channel depths to eliminate all delays for the largest vessels projected to use Richmond Harbor. However, the 38-foot depth provided will accommodate most of the domestic and foreign

bulk vessels expected to be serviced in the near future.

3.14. - Aids to Navigation

Channel reconfiguration in various reaches will necessitate the relocation of existing navigation aids or installation of new equipment at angle points and channel boundaries. These relocations or installations would be made by the U.S. Coast Guard, with the cooperation of the San Francisco Bar Pilots Association. The boundary of the new 1,260-foot-diameter turning basin will require installation of several new buoys during construction which will be in accordance with marine regulations and contingent upon directions by the Coast Guard.

3.15. - Modifications, Relocations, and Rights-of-Way

As stated in section 3.12.4., the Port and the San Francisco Bar Pilots have requested the removal of dolphin moorings and piles in the GATX berthing area to improve navigation and safety. The Port is resolving this issue at the local level. In addition, pending Coast Guard approval, Green Buoy 5 and Red Buoy 6 will be moved outside the channel (see Plate 2).

3.16. - Construction Schedule

Award of the construction contract is expected in August 1996. A clamshell dredge with a barge to the ocean disposal site is the assumed construction method. However, the contractor is not bound to this method of dredging. Construction of the deepened channel will require from 10 to 15 months to complete.

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4.0 Disposal Site Evaluation and Plan Selection

4.1. - Introduction

While Section Three focused on the engineering design and location of physical features in the project area, this section consists of identification and definition of the disposal alternatives, and the selection process by which the disposal plan for dredged material was chosen.

In addition, presented herein is the formulation of the preliminary disposal site alternatives and the final array of alternatives. Based on the comparison of the final array of alternatives, a recommended dredged material disposal plan was selected. This section also shows a *preliminary* cost estimate for each alternative.

4.2. - Dredging Measures

4.2.1. - Material to be Dredged

The dredged material has been broken down into two main categories: sediments suitable for unconfined open-water disposal, and sediments unsuitable for unconfined open-water disposal. Within these main categories, the sediments are broken down into the following six categories, which are not mutually exclusive: sediments suitable for ocean disposal; sediments suitable for in-bay disposal; sediments unsuitable for unconfined aquatic disposal; sediments suitable for use as cover in a wetland; sediments suitable for use as non-cover in a wetland; and sediments unacceptable for wetland use (see Figure 5). A brief description of each category is provided below.

4.2.1.1. - Sediments Suitable for Ocean Disposal

The suitability of dredged material for ocean disposal is regulated under the Marine Protection, Research, and Sanctuaries Act (MPRSA). Under that act, suitability is determined by a comparison of the results of bioassays and bioaccumulation tests of the sediments to be dredged to results of the same tests with ocean sediments. The EPA and Corps are responsible for reviewing the test data and determining acceptability for ocean disposal. Those agencies have determined that approximately 1.68 MCY of sediments from this project are acceptable for ocean disposal.

4.2.1.2. - Sediments Suitable for In-Bay Disposal

The suitability of dredged material for disposal in San Francisco Bay is regulated under the Clean Water Act (CWA) by the Corps, the EPA, the San Francisco Bay Conservation and Development Commission (BCDC), and the Regional Water Quality Control Board (RWQCB). Those four agencies have prepared guidance under the CWA that specifically addresses disposal at the Alcatraz aquatic site, which the Corps published as Public Notice 93-2. Suitability of sediments for Bay disposal is based on a tiered approach that evaluates

the sediment chemistry of the solid phase bioassay and bioaccumulation results of the dredged material compared to the same tests of Bay sediments near the Alcatraz site. The Corps and the EPA have determined that under these criteria, 1.68 MCY are suitable for In-Bay disposal.

4.2.1.3 - Sediment Unsuitable for Unconfined Aquatic Disposal

The Corps and the EPA have determined that approximately 234,000 CY of the Richmond material does not meet either the MPRSA or CWA criteria for unconfined aquatic disposal. Under an aquatic disposal alternative, this material would be disposed in the Parking Lot area near Point Potrero.

4.2.1.4. - Sediments Suitable for Wetland Cover Use

The RWQCB has developed interim screening criteria and testing requirements for wetland restoration and upland beneficial reuse of dredged material (RWQCB 1992). Under these criteria, suitability of material for use as cover material in a wetland restoration or creation project is determined by a comparison of solid phase bioassay and leachate test results of contaminant concentrations in the dredged sediment to set levels for heavy metals, polychlorinated biphenyls (PCBs), DDT and derivatives, and polyaromatic hydrocarbons (PAHs). At least 1.22 MCY of dredged material are suitable for use as cover in a wetland.

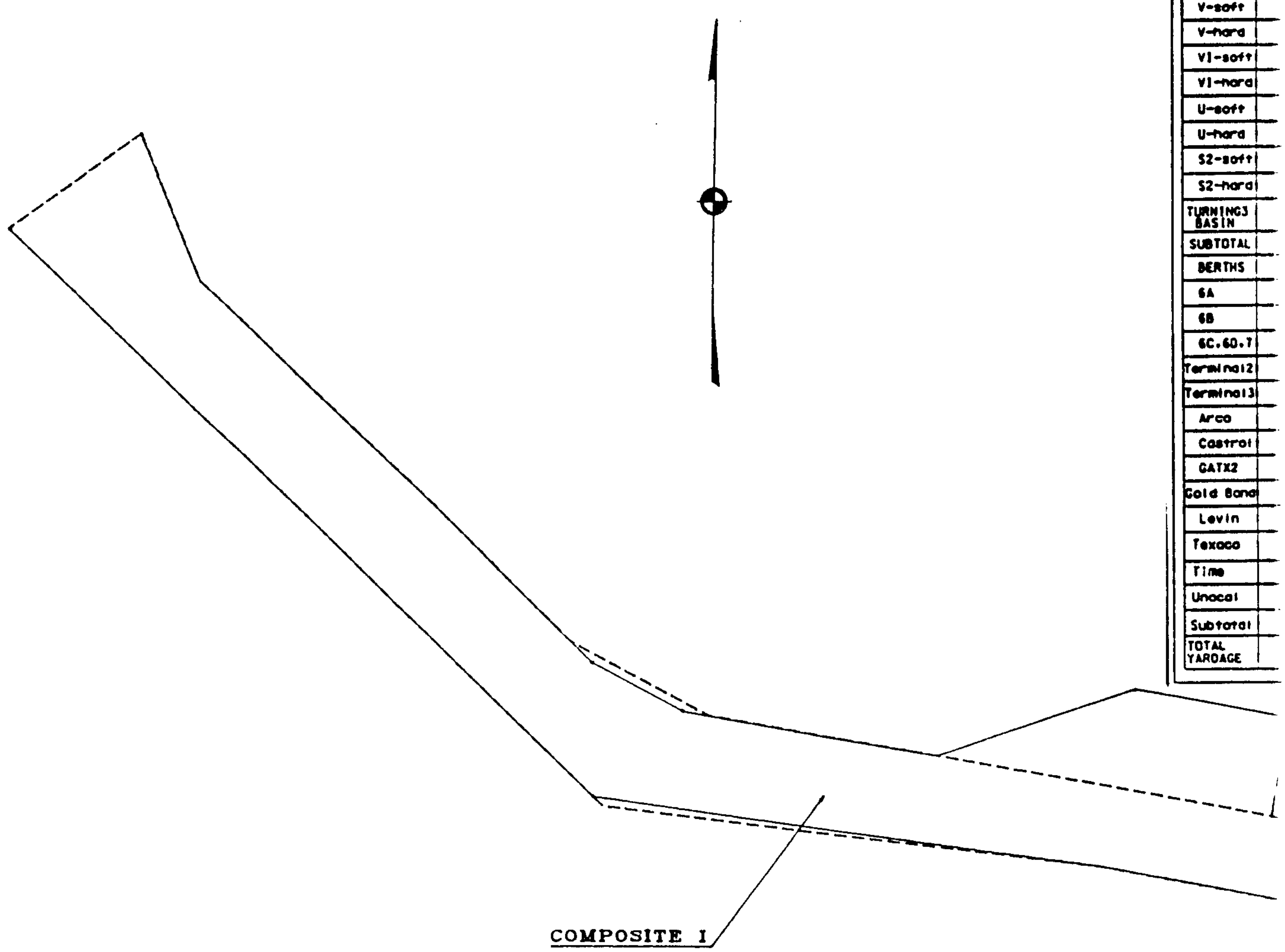
4.2.1.5. - Sediments Suitable for Wetland Non-Cover Use

For sediments that would be used as non-cover material (i.e., material to be buried three feet or more under cover material in a wetland creation or restoration project), suitability is determined by comparing leachate test results to set concentrations of heavy metals, PCBs, DDT and derivatives, and PAHs. Approximately 1.91 MCY of material (~686,000 CY only suitable for non-cover material and ~1.22 MCY suitable for wetland cover) is considered suitable for use as non-cover material in a wetland, without reference to RWQCB's chromium criterion.

4.2.1.6 - Unacceptable for Wetland Use

Based on discussion and meetings with RWQCB—and by comparing the Richmond material to the RWQCB interim screening criteria—it appears that all of the material is acceptable for either cover or non-cover wetland use. If, however, criteria should change, this material could be used for the Parking Lot near Point Potrero. Another option would be to take the material to a Class II or III landfill; Class I would not be required.

AREA
I-soft
II-soft
II-hard
V-soft
V-hard
VI-soft
VI-hard
U-soft
U-hard
S2-soft
S2-hard
TURNING3 BASIN
SUBTOTAL
BERTHS
6A
6B
6C,6D,7
Terminal2
Terminal3
Arco
Castrol
GATX2
Gold Bond
Levin
Texaco
Time
Unocal
Subtotal
TOTAL YARDAGE



RICHMOND H

NOTE:FOR ADDITIONAL INFORM

NOT TO SCA

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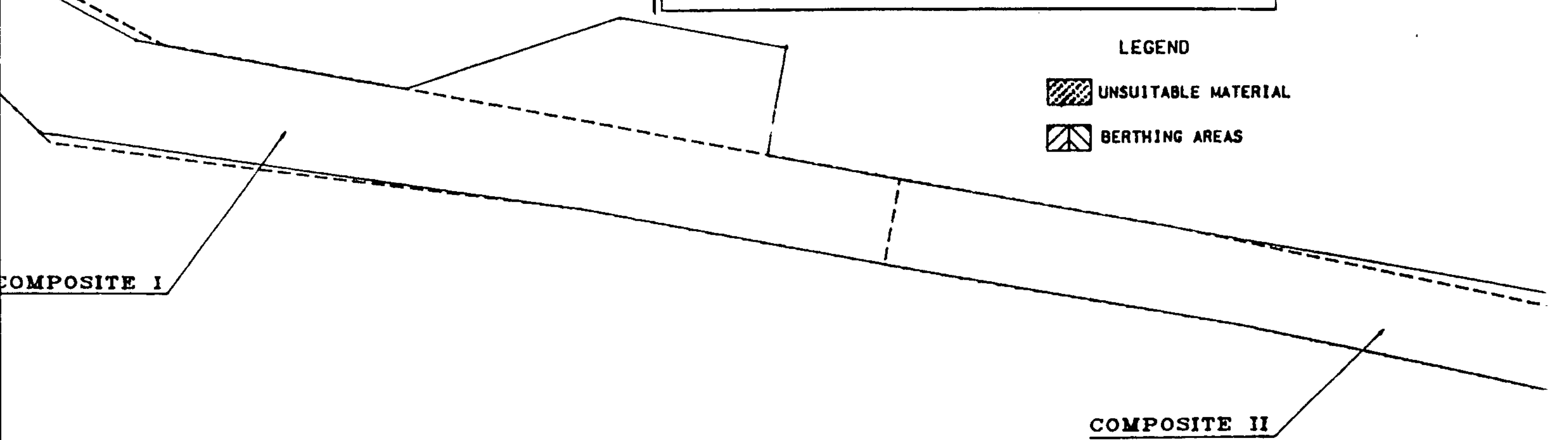
SEDIMENT VOLUMES			
AREA	38'+1' O.D.	MATERIAL UNSUITABLE FOR OCEAN DISPOSAL	MATERIAL SUITABLE FOR OCEAN DISPOSAL
I-soft	446.107 CY	0 CY	446.107 CY
II-soft	302.617	0	302.617
II-hard	78.216	0	78.216
V-soft	114.216	0	114.216
V-hard	37.676	0	37.676
VI-soft	139.155	0	139.155
VI-hard	44.670	0	44.670
U-soft	59.577	7.310	52.267
U-hard	22.887	2.442	20.445
S2-soft	37.252	37.252	0
S2-hard	12.276	12.276	0
TURNING3 BASIN	497.852CY	79.151 CY	418.701 CY
SUBTOTAL	1.792.501	138.431	1.654.070
BERTHS			
6A	N/A	N/A	N/A
6B	N/A	N/A	N/A
6C.6D.7	22.917	0	22.917
Terminal2	21.667	21.667	0
Terminal3	15.278	15.278	0
Arco	15.278	15.278	0
Castrol	N/A	N/A	N/A
GATX2	14.778	14.778	0
Gold Bond	4.889	4.889	0
Levin	10.666	10.666	0
Texaco	4.889	4.889	0
Time	4.926	4.926	0
Unocal	3.565	3.565	0
Subtotal	118.852	95.936	22.917
TOTAL YARDAGE	1.911.353 CY	234.367 CY	1.676.987 CY



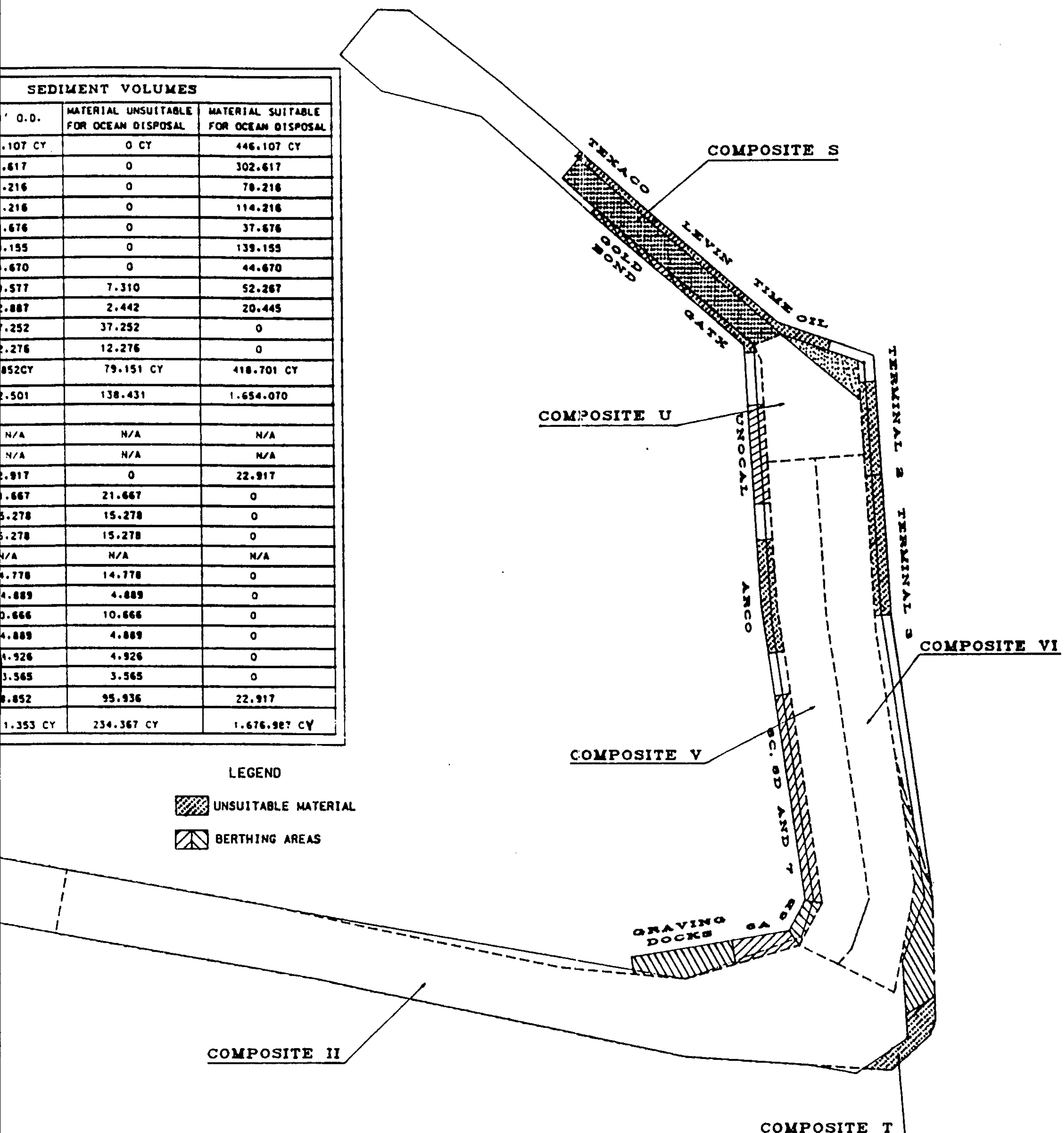
RICHMOND HARBOR

NOTE:FOR ADDITIONAL INFORMATION SEE FIGURE 2.

NOT TO SCALE

SEDIMENT VOLUMES

' O.D.	MATERIAL UNSUITABLE FOR OCEAN DISPOSAL	MATERIAL SUITABLE FOR OCEAN DISPOSAL
.107 CY	0 CY	446.107 CY
.617	0	302.617
.216	0	78.216
.216	0	114.216
.676	0	37.676
.155	0	139.155
.670	0	44.670
.577	7.310	52.267
2.887	2.442	20.445
7.252	37.252	0
2.276	12.276	0
852CY	79.151 CY	418.701 CY
2.501	138.431	1.654.070
N/A	N/A	N/A
N/A	N/A	N/A
2.917	0	22.917
.667	21.667	0
5.278	15.278	0
5.278	15.278	0
N/A	N/A	N/A
4.778	14.778	0
4.889	4.889	0
0.666	10.666	0
4.889	4.889	0
4.926	4.926	0
3.565	3.565	0
8.852	95.936	22.917
1.353 CY	234.367 CY	1.676.987 CY



RBOR

TION SEE FIGURE 2.

E

CONTRA COSTA COUNTY CALIFORNIA

RICHMOND HARBOR 38-FOOT PROJECT

PHASE I

SEDIMENT QUANTITY MAP

IN SHEET SHEET NO.

U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E

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CHECKED: DATED

3

4.2.2. - Types of Equipment

4.2.2.1. - Hopper Dredge

The hopper dredge is a self-propelled, ocean-going vessel that removes material from the bottom of the bay or ocean by scraping and sucking material through pipes known as drag pipes, which are trailed on the sides of the vessel. The vessel pumps the dredged material into bins or hoppers and then discharges it later at the disposal site by bottom dumping. Because of its size, the hopper dredge disturbs bottom sediment as it moves. However, this occurs with any relatively deep-draft vessel. The cutting motion of the dredge also disturbs sediments. During loading, overflow periods return some sediments to the water column. This activity does not have a known long-term effect on water quality.

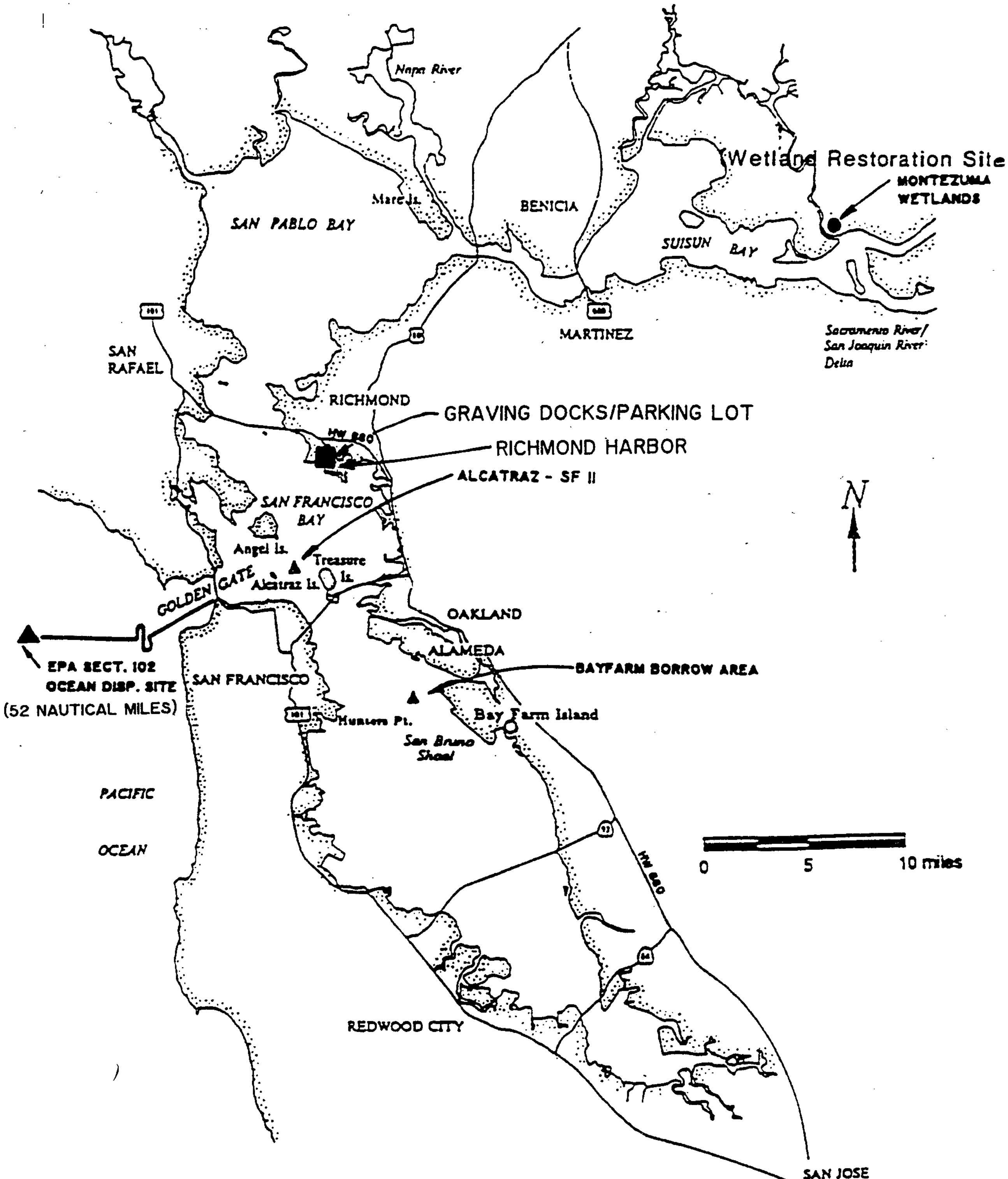
4.2.2.2. - Clamshell Dredge and Barge

Clamshell dredges remove sediment by dropping a bucket that sinks into the sediment. The bucket is raised and dumped into a barge, which when full carries the sediment to the disposal site where it is discharged by bottom dumping or direct pumpout. Turbidity occurs as the clamshell bucket bites into the sediment and breaks free when it is hoisted. The bucket also loses sediment as it is lifted through the water and as it breaks free of the water surface and is swung to the barge.

4.2.3. - Types of Sites

Disposal within nearshore areas in the San Francisco Bay has traditionally been both unconfined and confined. Nearshore confined areas played a major role in the development of industrial, commercial, and residential land until the 1970's when public policy began to restrict placement of fill for development purposes severely. The number of sites for open water in-Bay disposal has decreased from eleven in the early 1970's to four sites today. The four remaining in-Bay disposal sites are the San Francisco Bar channel, Alcatraz Disposal site (SF-11), San Pablo Bay Disposal site (SF-10), and the Carquinez Straits Disposal site (SF-09). Designation of new in-Bay sites must meet the requirements of Section 404(b)(1) of the Clean Water Act of 1972 that regulates the discharge of dredged material within waters of the United States. The Corps of Engineers regulates this discharge, with the oversight of EPA, and the State and Regional Water Quality Control Boards have responsibility for issuing water quality certification under Section 401 of the CWA.

The remainder of this section provides a brief description of each disposal site type under consideration. There are primarily three categories of sites for use in this project. They include upland disposal sites (which also includes wetland restoration), aquatic in-bay open-water disposal sites, and candidate Ocean sites (see Figure 6). The definitions for identified sites are provided below.



LEGEND:

▲ – AQUATIC DISPOSAL SITE

● – UPLAND DISPOSAL SITE

■ UNSUITABLE FOR AQUATIC DISPOSAL SITE

CONTRA COSTA COUNTY	CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT PHASE I	
DISPOSAL SITES	

IN SHEET SHEET NO
U.S. ARMY ENGINEER DIST. SAN FRANCISCO. C OF E
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FIGURE 6

4.2.3.1. - In-Bay, Open-Water Disposal

In-Bay, open-water disposal consists of placement into an unconfined, open water area in an ocean, river, or bay. This option is available for uncontaminated sediment placement only and may have associated beneficial uses. Open water placement is acceptable whether the intent is for the material to disperse or to remain in a stable mound. Sometimes open-water and upland alternatives are combined and called Confined Disposal Facilities (CDFs). A method of "combined" open-water disposal, used for both uncontaminated and contaminated sediments, includes partial placement into a confined area underwater, nearshore, or upland. Recolonization of the disposal area and other biological impacts may be a concern and require monitoring.

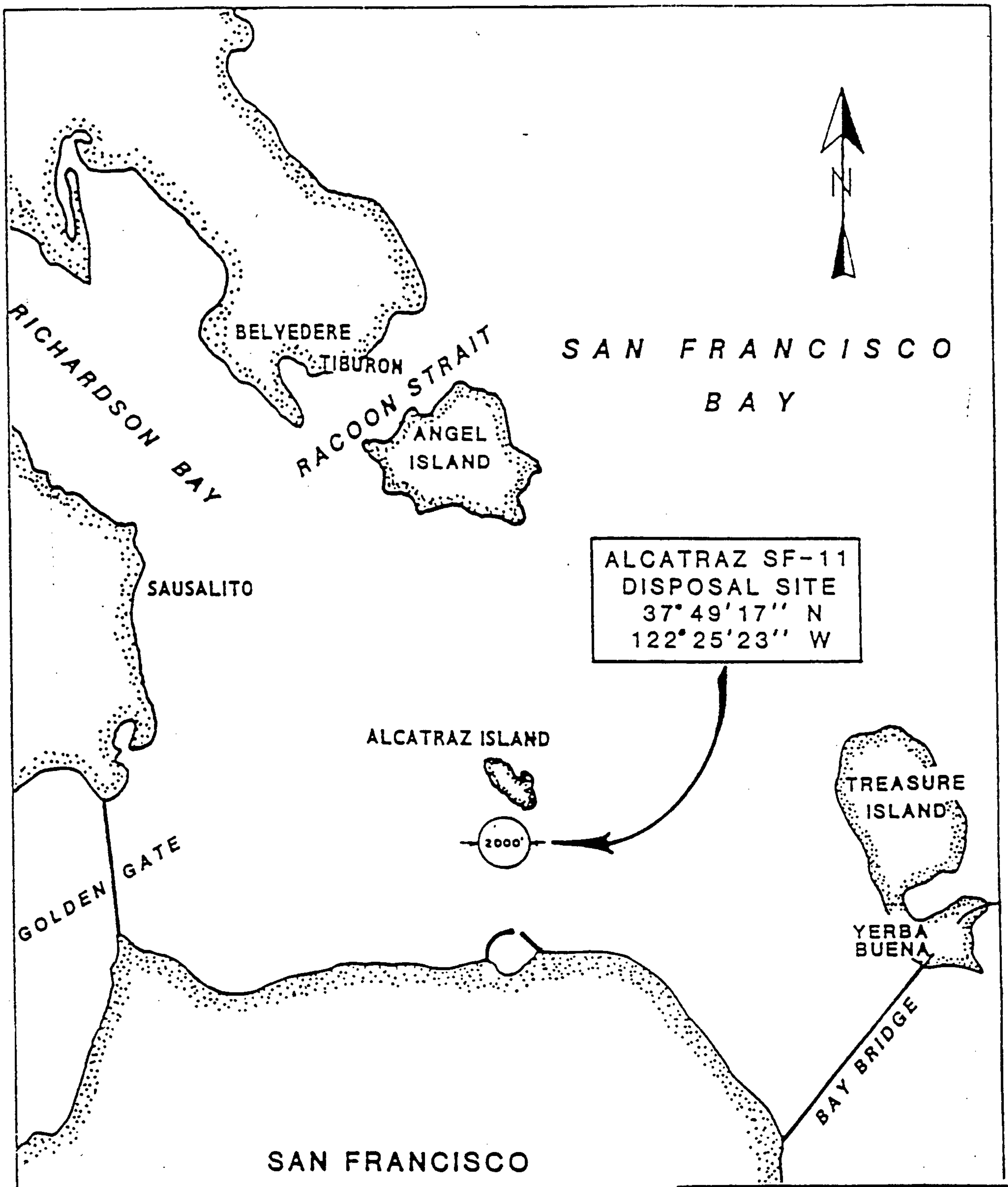
4.2.3.1.1. - Alcatraz Island

The Alcatraz disposal site, also known as SF-11, is a 2,000-foot circle centered at 37° 49' 17" N by 122° 25' 23" W and is in Central San Francisco Bay between Alcatraz Island and Fisherman's Wharf, San Francisco. This site has been used since the late 1800's for disposal of dredged material. Since being formally designated in 1972, it has been the most widely used dredged material disposal site in the Bay Area, and is the primary disposal site for Richmond Harbor O&M material. (The site was originally selected because of its depth and the swift tidal currents that occur in the area.) The Composite Environmental Impact Statement (USACE, 1975) reports the depth of water over the Alcatraz site ranged from 95 to 160 feet. Currently, the water depth ranges from 35 to 100 feet. Also, the currents are predicted to disperse disposed sediment over a large area of the Bay and ocean. The position of the site close to the Golden Gate Bridge is presumed to accelerate transport of disposed material to the ocean; however, a portion of the material does accumulate at the site. (See Figure 7.)

4.2.3.1.2. - Bay Farm Borrow Pit

The Borrow area is an aquatic site found west of Bay Farm Island in San Francisco Bay. The Corps originally dredged the site to provide sediments used to create fastland on Bay Farm Island in the 1950's. The area is roughly 2 by 0.5 nautical miles (NM) with a water depth ranging from -27 to -48 feet MLLW. Depths in the surrounding areas range from -0.5 feet nearshore to -11 feet MLLW deep near the extreme western end of the Borrow area. Currents are relatively slow, and the site may be non-dispersive. Recent surveys conducted by the Hydrological Branch of the Corps of Engineers, showed that fine-grained Bay sediments have settled in the Borrow area, including some material considered contaminated. The controlling depth for barge access is about 14 feet MLLW. This site could contain more than 8 MCY with fill to -20 feet MLLW or more than 13 MCY with fill to -15 feet MLLW. (See Figures 8, 9, and 10.)

The alternative consists of aquatic disposal and introduces the idea of capping dredged material at a disposal site. Capping is the controlled, accurate placement of contaminated material at an open-water disposal site, followed by a covering or cap of clean isolating material. It is the burial of contaminated material with stable layers of clean dredged material,



NOT TO SCALE

CONTRA COSTA COUNTY	CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT PHASE I	
ALCATRAZ DISPOSAL SITE	
IN SHEET	SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E	
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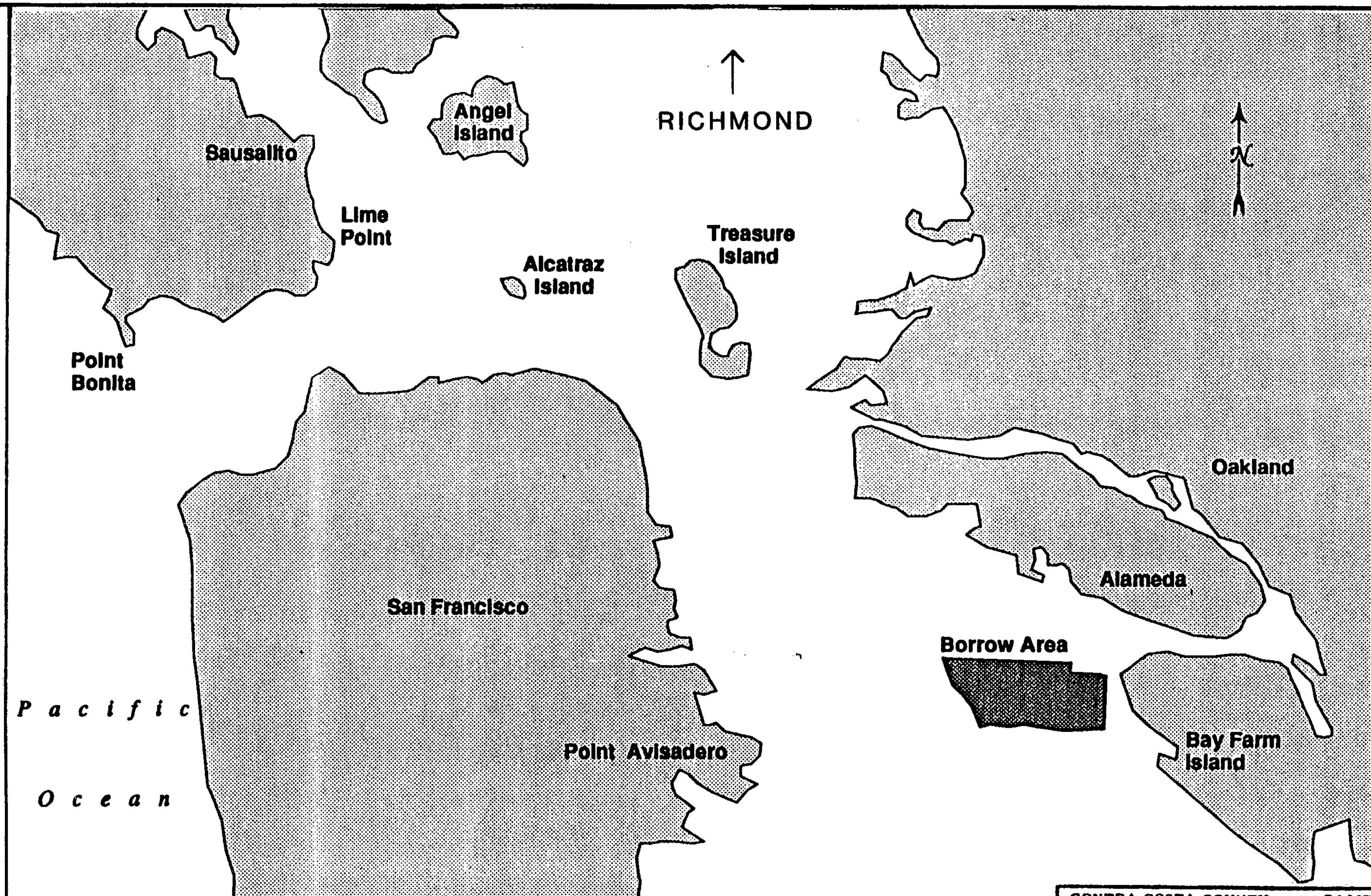
TRACED:	TO ACCOMPANY REPORT
CHECKED:	DATED

FIGURE 11



Source: PTI 1989. Central San Francisco Bay Projects - Dredged Material Disposal Site Investigation, November.

Scale

0 5 10

Miles

CONTRA COSTA COUNTY	CALIFORNIA

RICHMOND HARBOR 38-FOOT PROJECT
PHASE I

BAY FARM ISLAND
BORROW AREA

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO
TRACED: TO ACCOMPANY REPORT
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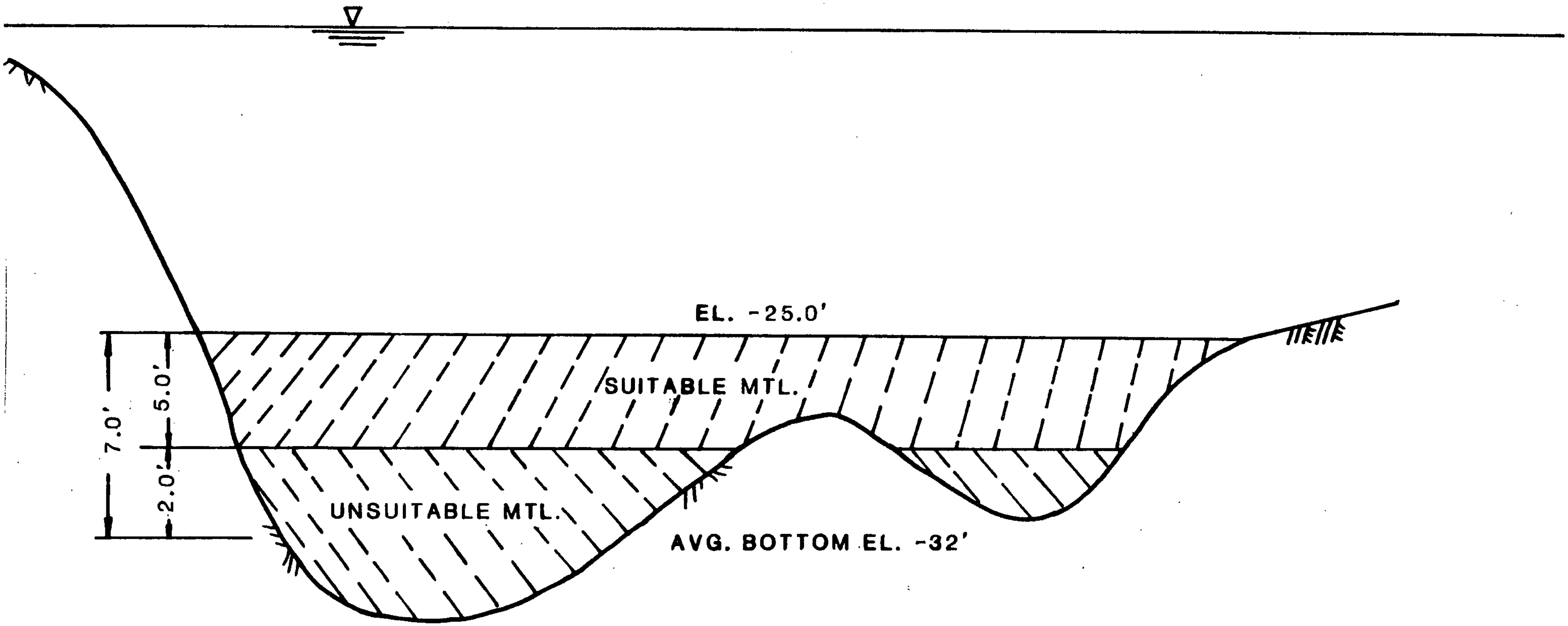
FIGURE 8

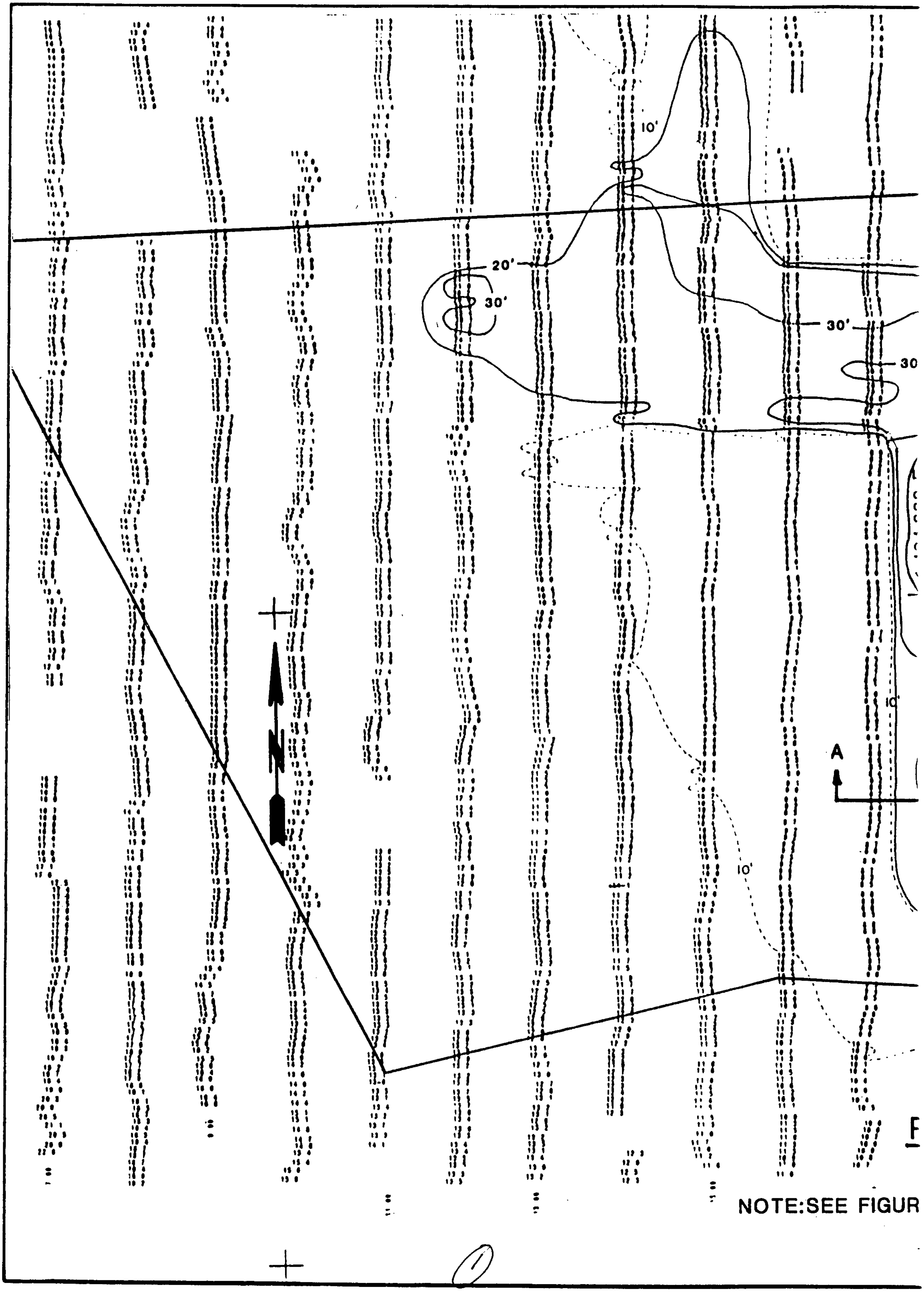


SECTION A–A
N.T.S.

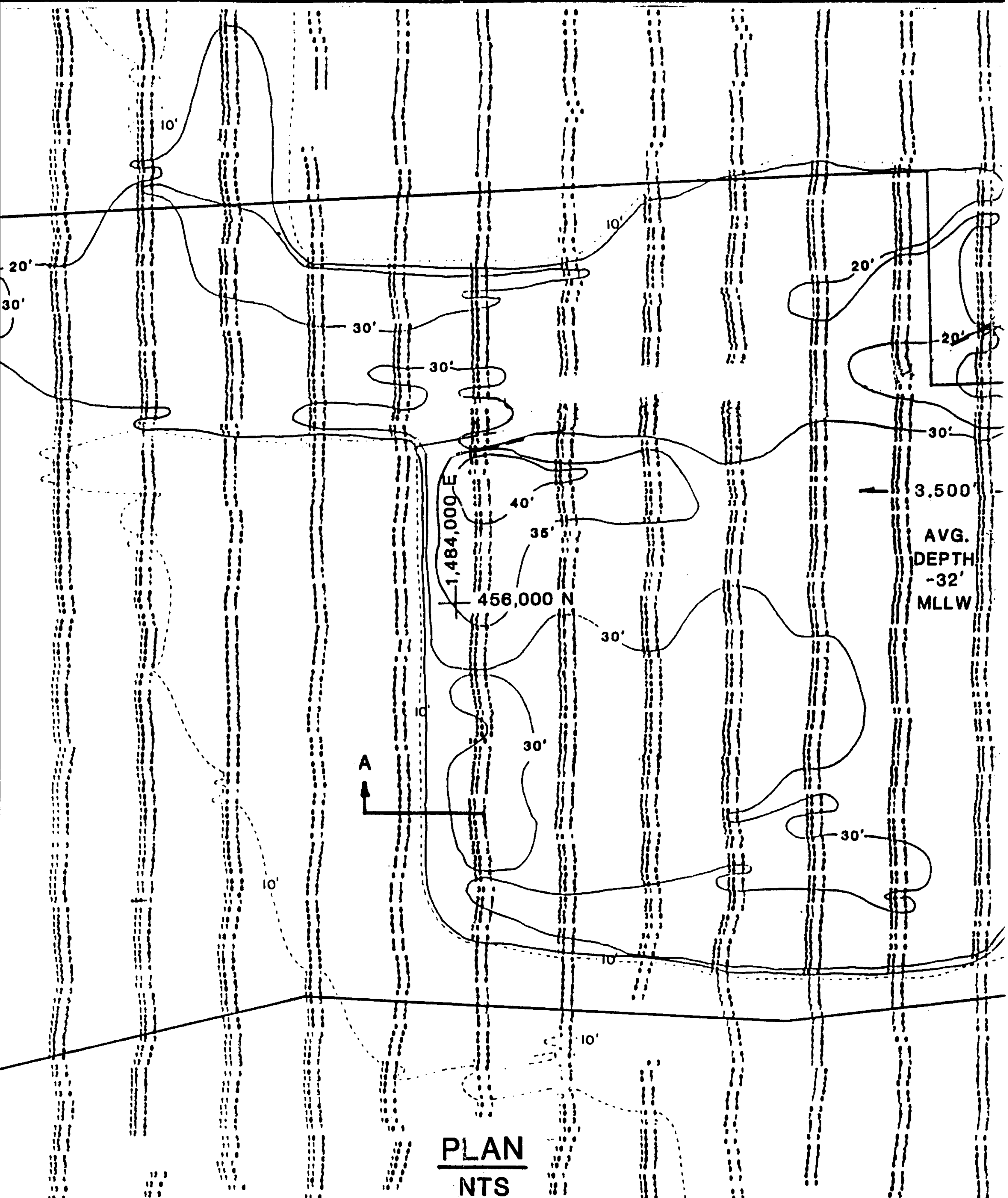
NOTE: FOR LOCATION OF SECTION A–A SEE FIGURE 10.

CONTRA COSTA COUNTY	CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT PHASE I	
BAY FARM ISLAND BORROW AREA SECTION	
IN SHEET	SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E	
DRAWN:	FILE NO
TRACED	TO ACCOMPANY REPORT
CHECKED:	DATED

FIGURE 9



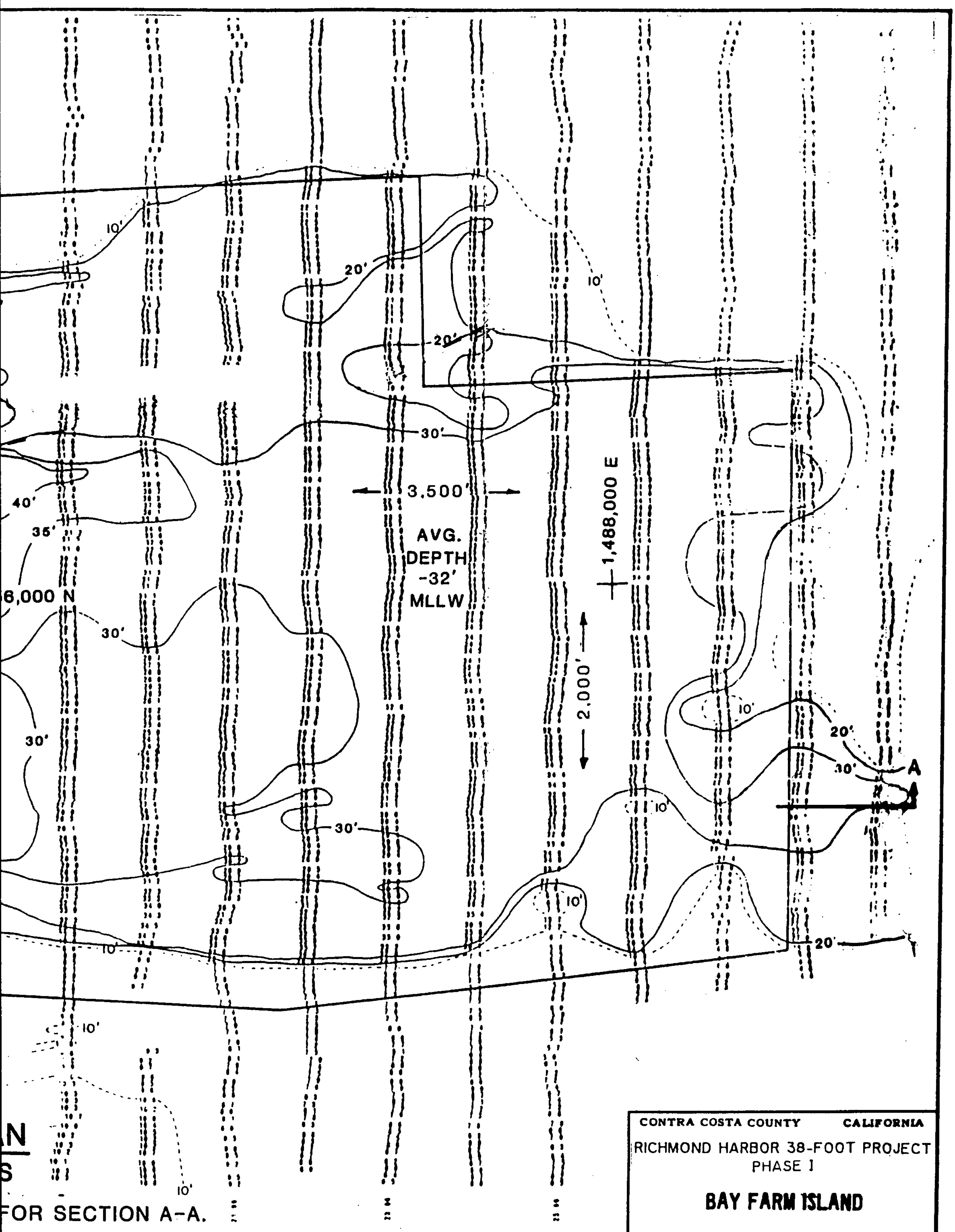
NOTE:SEE FIGUR



PLAN
NTS

NOTE:SEE FIGURE 9 FOR SECTION A-A.

2



CONTRA COSTA COUNTY CALIFORNIA

RICHMOND HARBOR 38-FOOT PROJECT
PHASE I

BAY FARM ISLAND

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO.
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3

thereby, isolating contaminants from the water column and benthic organisms.

4.2.3.2. - Candidate Ocean Disposal Sites

Ocean disposal refers to the transportation of dredged material in hopper dredges or barges to the ocean for disposal. Disposal must be to a site designated and permitted under either Section 102 or Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972. The Environmental Protection Agency designates section 102 sites (EPA); the U.S. Army Corps of Engineers permits section 103 sites (USACE) in concurrence with the EPA. Material for ocean disposal must be evaluated for environmental impacts by applicable criteria published in Title 40, Code of Federal Regulations, Paragraphs 220-228 (40 CFR 220-228).

4.2.3.2.1. - EPA Designated Ocean Site

The EPA Designated Ocean site is on the continental rise off San Francisco about 52 nautical miles from shore and in 8,200 to 9,850 feet of water. The proposed ocean site provides a disposal option for approximately 6,000,000 CY of dredged material per year for 50 years. The site was designated May 1994. (See Figure 11.)

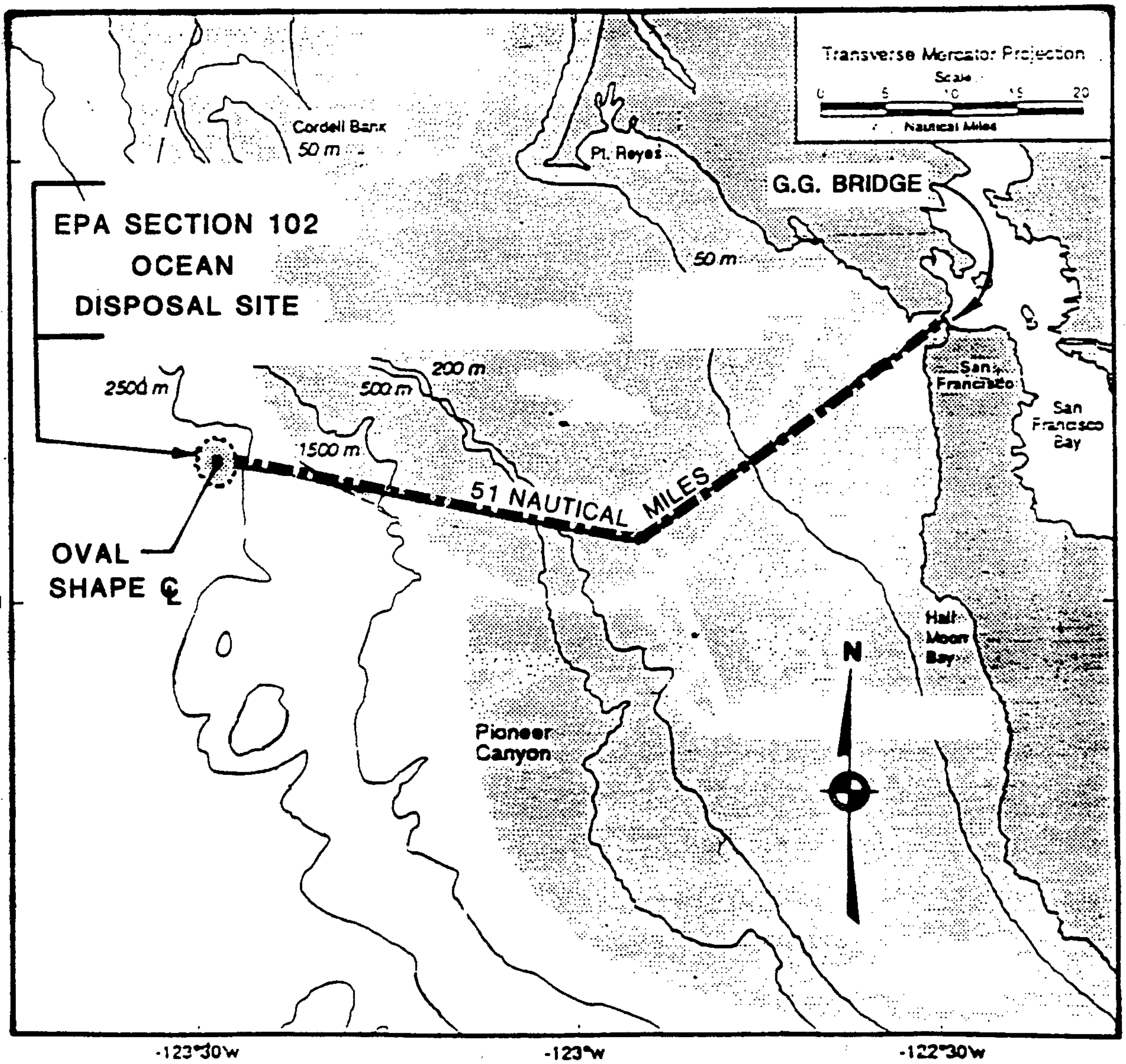
4.2.4. - Montezuma Wetlands (Habitat Restoration)

The Montezuma restoration project of a diked historical marshland will eventually recreate approximately 2,000 acres of tidal brackish marsh. The site is between Birds Landing and Collinsville, east of Montezuma Slough and bordered to the south by the Sacramento and San Joaquin River confluence. The Ogden Beeman report identified the site as feasible in the 1988. Levine-Fricke, the current owners, plans to restore approximately 2,000 acres to tidal marsh wetlands by placing dredged material on the site. The entire site comprises a total of approximately 4,000 acres. Currently about 2,000 acres of the site are subsided historical marshland; the other 2,000 acres are open upland grasslands. An oyster shell and sand reclamation facility operates in and beside a tidal channel. Levine-Fricke has submitted a permit application for the Montezuma Marsh Restoration Project to the Corps of Engineers, and a draft EIS is under preparation for public review. (See Figure 12.)

4.2.5. - Upland Disposal

4.2.5.1. - Graving Docks

The graving docks disposal site is located near the Point Potrero Sharp Turn and consist of five basins formerly used as dry docks for ship construction and repair during WWII. The site plan involves: (1) removal of a craneway, backlands, and a building, (2) reinforcement of the existing east wharf and construction of a west wharf, and (3) filling basins one and five—each of a capacity up to 89,000 CY— with dredge material unsuitable for ocean disposal. Before filling and capping the two basins, all material would be spread on 7 to 11 acres beside Basin 1, and then dried and compacted (see Figures 13 and 14). The remaining 56,000 CY of unsuitable material will be transported and disposed at an upland site (for estimating purposes it was assumed that this material would be trucked to the Vasco Road Landfill in Livermore).



EPA SECTION 102
OCEAN DISPOSAL SITE

OVAL SHAPE, ℄ COORDINATES: 37° 39.0' N (1983)
123° 29.0 W (1983)

LENGHT: 4 NAUTICAL MILES (N - S)

WIDTH: 2.5 NAUTICAL MILES (E - W)

CONTRA COSTA COUNTY	CALIFORNIA

RICHMOND HARBOR 38-FOOT PROJECT
PHASE I

EPA SECT 102
OCEAN DISP. SITE

IN SHEET SHEET NO
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: DATED

FIGURE 11

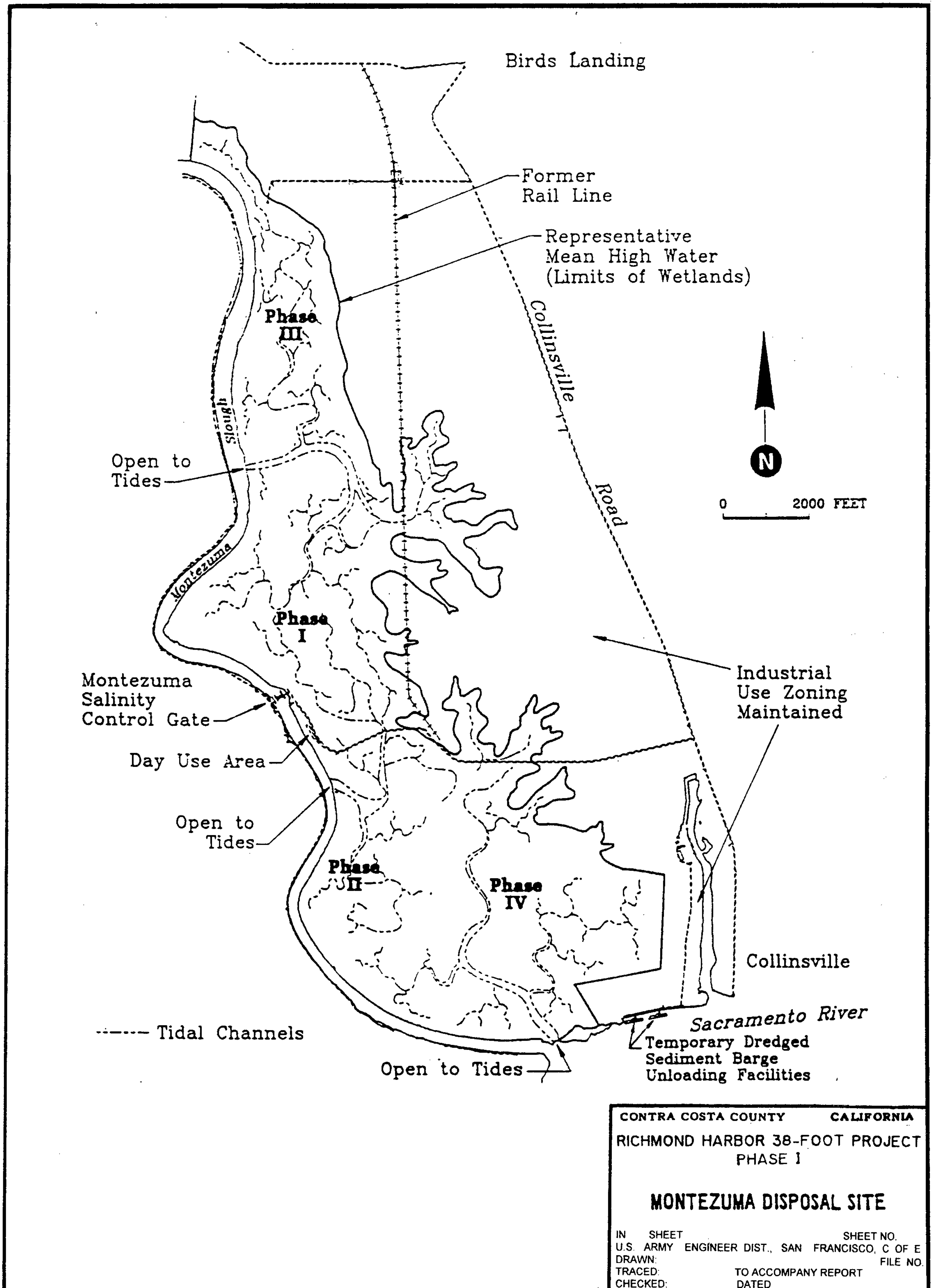

Birds Landing
Former Rail Line
Representative Mean High Water (Limits of Wetlands)
Collinsville Road
Phase III
Montezuma Slough
Open to Tides
0 2000 FEET
N
Phase I
Industrial Use Zoning Maintained
Montezuma Salinity Control Gate
Day Use Area
Open to Tides
Phase II
Phase IV
Collinsville
Tidal Channels
Sacramento River
Temporary Dredged Sediment Barge Unloading Facilities
Open to Tides
CONTRA COSTA COUNTY CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT PHASE I
MONTEZUMA DISPOSAL SITE
IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: DATED

FIGURE 12

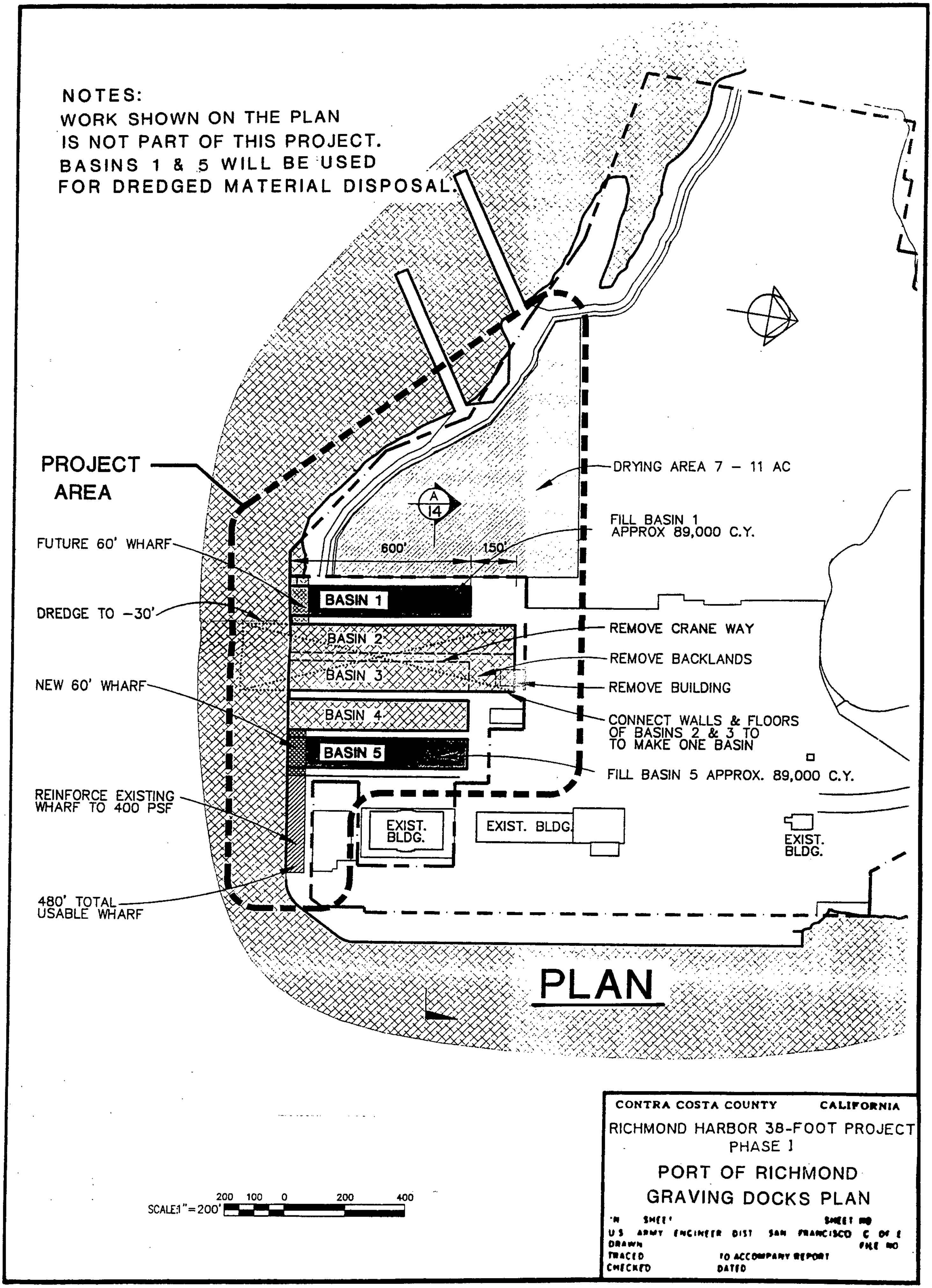
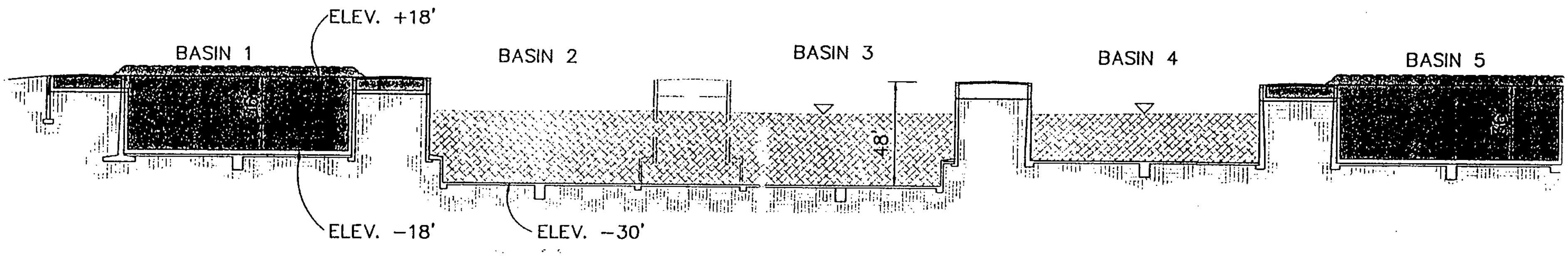

NOTES:
WORK SHOWN ON THE PLAN
IS NOT PART OF THIS PROJECT.
BASINS 1 & 5 WILL BE USED
FOR DREDGED MATERIAL DISPOSAL.
PROJECT AREA
DRYING AREA 7 – 11 AC
A
14
FILL BASIN 1
APPROX 89,000 C.Y.
FUTURE 60' WHARF
600'
150'
BASIN 1
DREDGE TO –30'
BASIN 2
REMOVE CRANE WAY
REMOVE BACKLANDS
BASIN 3
REMOVE BUILDING
NEW 60' WHARF
BASIN 4
CONNECT WALLS & FLOORS
OF BASINS 2 & 3 TO
TO MAKE ONE BASIN
BASIN 5
FILL BASIN 5 APPROX. 89,000 C.Y.
REINFORCE EXISTING
WHARF TO 400 PSF
EXIST.
BLDG.
EXIST. BLDG.
EXIST.
BLDG.
480' TOTAL
USABLE WHARF
PLAN
200 100 0 200 400
SCALE:1"=200'
CONTRA COSTA COUNTY CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT
PHASE 1
PORT OF RICHMOND
GRAVING DOCKS PLAN
U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF E
DRAWN
TRACED
CHECKED
TO ACCOMPANY REPORT
DATED

FIGURE 13



TYPICAL FOR FILLED CONDITION

SECTION A/13

LEGEND

BAY FILL MATERIAL

WATER

CONTRA COSTA COUNTY CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT
PHASE I

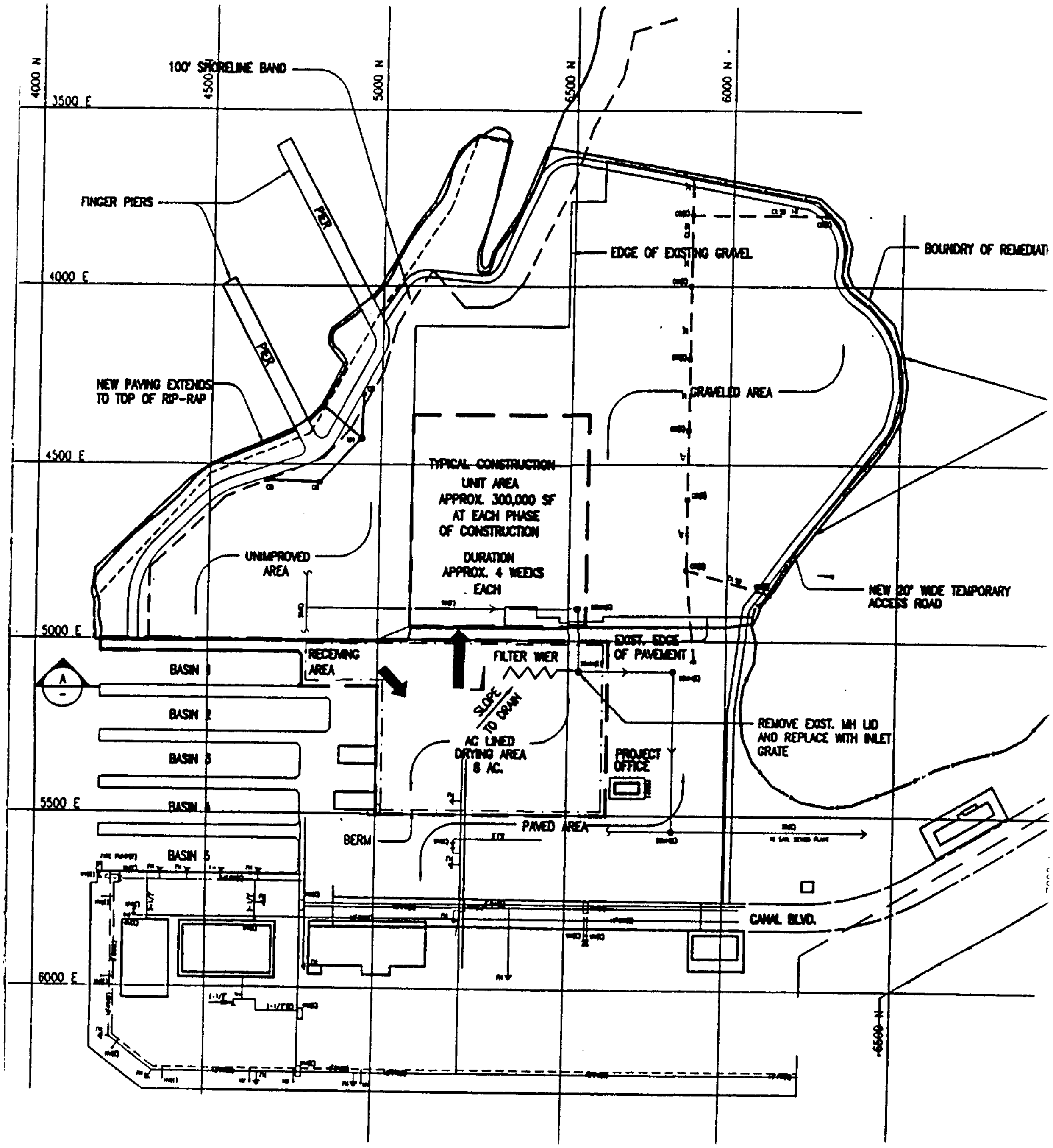
PORT OF RICHMOND
GRAVING DOCKS
CROSS SECTION

U.S. ARMY ENGINEER DIST SAN FRANCISCO C OF E
DRAWN FILE NO
TRACED TO ACCOMPANY REPORT
CHECKED DATED

4.2.5.2. - Parking Lot

The 46-acre parking lot disposal site borders the aforementioned drying area, northwest of the graving docks, near the Point Potrero Sharp Turn. This site is part of a Remediation Action Plan, overseen by the State of California Department of Toxic Substance Control, designed to cover the asbestos-contaminated parking lot. The current design calls for a minimum of 24 inches protective cover over existing native soil or fill capped with 4 inches of asphalt. This layer will range between: (1) an existing 6-inch aggregate base, at least 14 inches of compacted fill (unsuitable dredge material), and a 4-inch aggregate base; and (2) at least 20 inches of compacted fill (unsuitable dredge material) and a 4-inch aggregate base. It should be noted that the Port can increase the protective layer thickness, from an engineering standpoint, to hold additional compacted fill. As a result, it will not be a significant problem if the volume of unsuitable material is more than 234,000 CY.

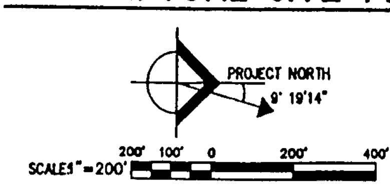
The Port is in the process of obtaining the authority from the State for the remediation plan. In addtion, they are pursuing permits from the Corps and BCDC in order to begin dredging and drying unsuitable berthing area material before the scheduled start of construction in August, 1996. (See Figure 15.)



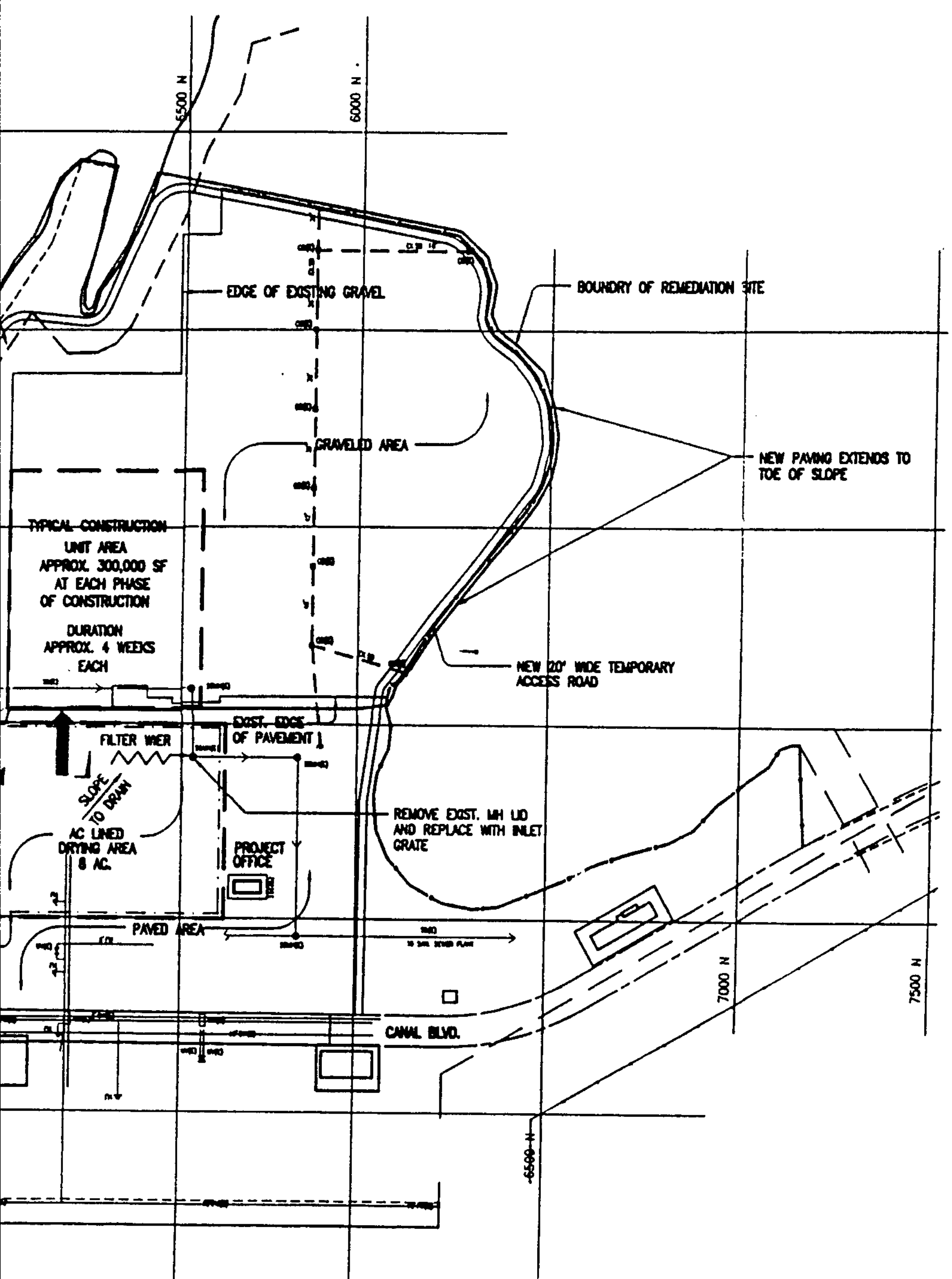
LEGEND

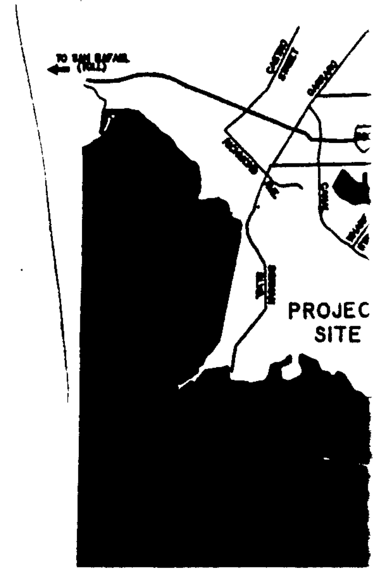
——x——x——	EXISTING FENCE LINE
CB(E) ■	EXISTING DRAINAGE INLET
CB ■	PROPOSED DRAINAGE INLET
SS	SANITARY SEWER
SD	STORM DRAIN
OTF	OUTFALL
AC	ASPHALT CONCRETE

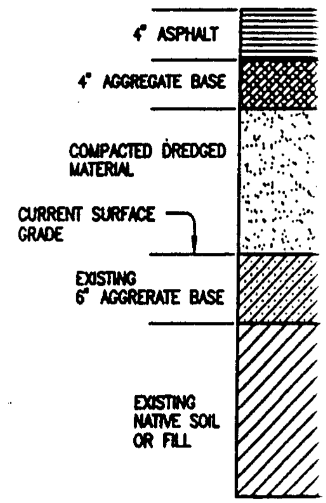
CONCEPTUAL SITE PLAN



NOTE:
PROJECT COORDINATES N 5000.00, E 5000.00 EQUALS N 517586.40, E 1461358.85
CALIF. COORDINATES SYSTEM, ZONE 3
BASIC FOR CALIFORNIA COORDINATE SYSTEM ZONE 3 VALUES IS CORPS OF ENGINEERS MONUMENT "HL9B 1983", DISTANCES AND VALVES THEREAFTER ARE BASED ON GROUND LEVEL MEASUREMENT.

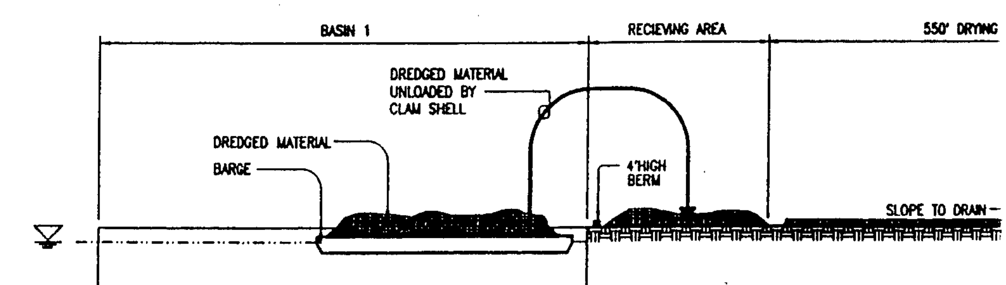






GRAVELL
CROSS
N.T

NOTE: MINIMUM 24" PROTECTIVE
ACHIEVE PROPER GRADIN



SECTION A
N.T.S.

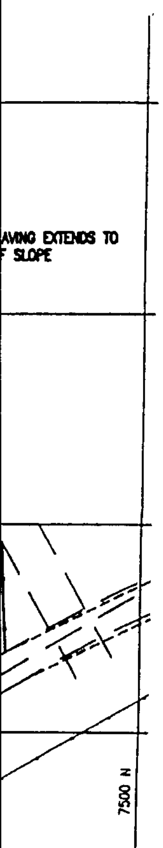
L SITE PLAN

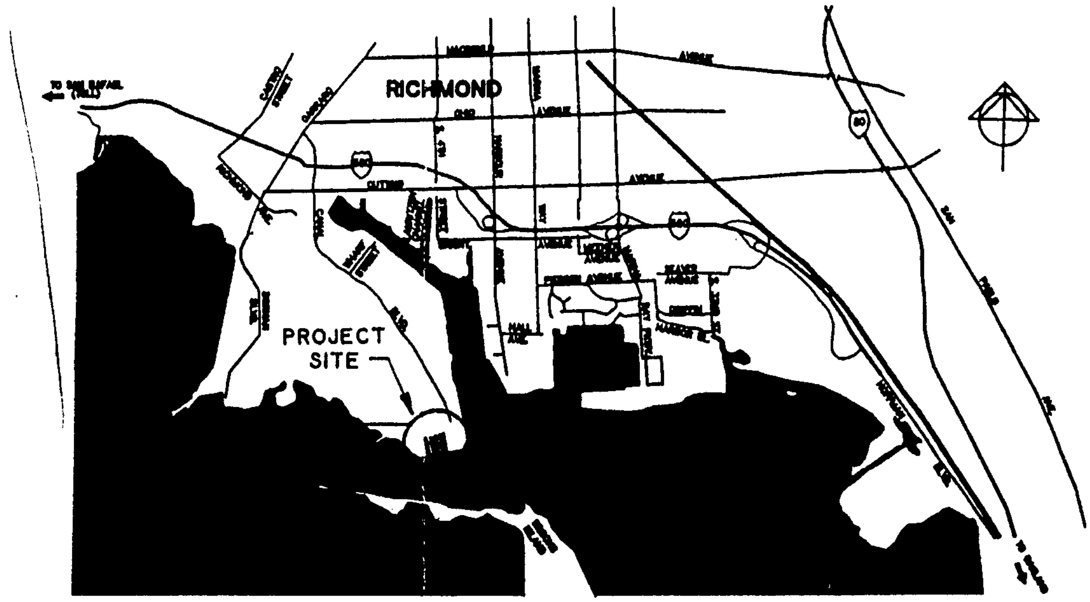
ROJECT NORTH
9° 19'14"

200' 400'

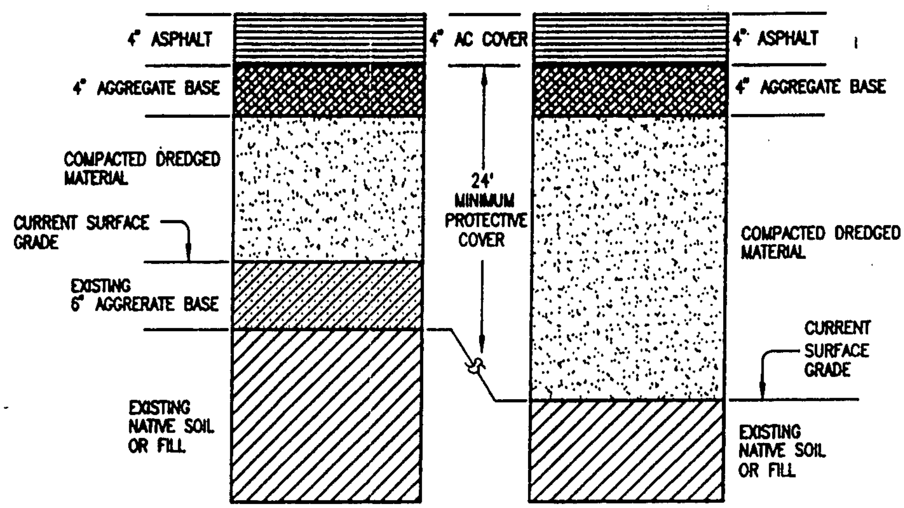
5000.00 EQUALS N 517586.40, E 1461358.85

YSTEM ZONE 3 VALUES IS CORPS OF ENGINEERS MONUMENT
S THEREAFTER ARE BASED ON GROUND LEVEL MEASUREMENT.





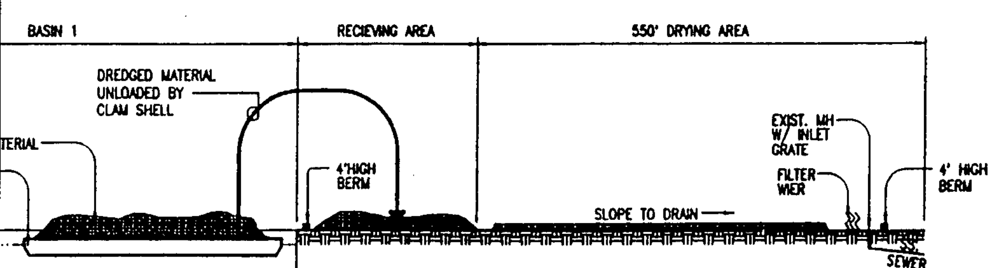
VICINITY MAP



GRAVELED AREA CROSS SECTION
N.T.S.

UNIMPROVED AREA CROSS SECTION
N.T.S.

NOTE: MINIMUM 24" PROTECTIVE COVER MAY BE THICKER IN UNIMPROVED AREAS TO ACHIEVE PROPER GRADING AND DRAINAGE.



SECTION (A/-)
N.T.S.

CONTRA COSTA COUNTY	CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT PHASE I	
PARKING LOT PLAN	
PORT OF RICHMOND	
IN SHEET	SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E	
DRAWN:	FILE NO.
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3

4.3. - <u>General Description of Disposal Alternatives</u>

4.3.1. - Alt. A (Montezuma Wetlands)

This alternative consists of disposal at an upland location consisting of 1.91 MCY at Montezuma Wetlands (~1.22 MCY used as cover material for 686,000 CY of non-cover material).

4.3.1.1 - Alt. A1 (Montezuma/Parking Lot)

This alternative consists of disposal of 1.68 MCY at Montezuma Wetlands (~1.22 MCY used as cover material and for 456,000 CY of non-cover material) and 234,000 CY of material unsuitable for aquatic disposal used as fill for a 46-acre parking lot near Point Potrero.

4.3.2. - Alt. B (Bay Farm Island Borrow Area)

This alternative consists of disposal of 1.91 MCY at Bay Farm Borrow Area (1.68 MCY used as cover material for 234,000 CY of unsuitable material).

4.3.3. - Alt. C (Ocean Disposal w/Graving Docks)

This alternative consists of disposal at two locations including 1.68 MCY at an EPA designated Ocean site for dredged material considered suitable for open-water disposal, and disposal of approximately 234,000 CY of material unsuitable for aquatic disposal (178,000 CY requiring confinement in the Graving Docks and 56,000 CY requiring upland disposal).

4.3.3.1 - Alt. C1 (Ocean/Montezuma)

This alternative consists of disposal at two locations: (1) 1.21 MCY at an EPA designated Ocean site for dredged material considered suitable for open-water disposal, and (2) disposal of approximately 234,000 CY of material unsuitable for aquatic disposal in the upland Montezuma Wetlands site with 468,000 CY of suitable material used as cover.

4.3.3.2 - Alt. C2 (Ocean/Parking Lot)

This alternative consists of disposal at two locations including 1.68 MCY at an EPA designated Ocean site for dredged material considered suitable for open-water disposal, and disposal of approximately 234,000 CY of material unsuitable for aquatic disposal used as fill for a 46-acre parking lot near Point Potrero

4.3.4. - Alt. D (Alcatraz with Graving Docks)

This alternative consists of disposal of 1.68 MCY at Alcatraz, and placement of 234,000 CY in the Graving Docks (material unsuitable for aquatic disposal) for an estimated volume of 1.91 MCY.

4.3.5. - Quantity Distributions

The total estimated volume is 1.91 MCY (see Figure 5 for a breakdown of the quantity estimates). For each alternative, Table 2 lists the dredged material quantities at each of the various disposal sites.

4.3.6. - Preliminary Cost Estimates

Cost estimates for the preliminary alternatives are summarized in Table 3 and shown individually in Table 4. For complete MCACES cost estimates and a list of assumptions for Alternatives A-D, see Appendix E.

Table 2

Disposal Alternative Volumes
(cubic yards)

Alternative	Montezuma	Bay Farm	Ocean	Alcatraz	Graving	Parking Lot
A	1,911,000					
A1	1,677,000					234,000
B		1,911,000				
C			1,677,000		234,000[1]	
C1	702,000		1,209,000			
C2			1,677,000			234,000
D				1,677,000	234,000[2]	

Table 3
Summary
Preliminary Cost Estimates
($000)

	Alternative	*Cost Estimate*
A	Montezuma Wetlands	$37,149
A1	Montezuma/Parking Lot	$37,487
B	Bay Farm Island Borrow Area	$28,336
C	Ocean Disposal with Graving Docks	$43,879
C1	Ocean/Montezuma (2:1 cover)	$35,096
C2	**Ocean/Parking Lot**	**$33,693**
D	Alcatraz with Graving Docks	$31,127

---

[1]Of which 56,000 CY is assumed—for cost estimating purposes—to be trucked to the Tasco Road Landfill in Livermore, CA.

[2]Ibid.

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TABLE 4
Preliminary Cost Estimates
ALTERNATIVE A
Montezuma Wetlands
($000)

Item	Quantity	Unit	Unit Price	Total Cost
Mob & Demob				
Clamshell Plant	1	Job	LS	$1,093
Dredging				
Bay Mud (soft)	1,597,000	CY	$5.56	$8,871
Bay Mud (hard)	196,000	CY	$13.89	2,722
Rock	7,000	CY	$45.01	315
Subtotal				$11,909
Other GNF				
E&D, Dredging	1	Job	LS	237
SIOH, Dredging	1	Job	LS	541
Subtotal				$778
Additional O&M	11,210	CY	$3.79	$42
PED (Sunk Cost)				
Thru FY 95	1	Job	LS	$8,208
FY 96 (Est.)	1	Job	LS	895
Subtotal				$9,104
Total GNF				$22,926
Berthing Areas				
Mont. Dredge & Trans.	119,000	CY	$5.56	$662
Tipping Fee @ Mont.	119,000	CY	$7.00	833
Subtotal				$1,495
LERRD				
Tipping Fee - Fed. Drdg.	1,800,000	CY	$7.00	$12,600
Aids to Navigation	1	Job	LS	$129
Total First Costs				**$37,149**

TABLE 4, (continued)
Preliminary Cost Estimates
ALTERNATIVE A1
Montezuma/Parking Lot
($000)

Item	Quantity	Unit	Unit Price	Total Cost
Mob & Demob				
Clamshell Plant	1	Job	LS	$1,284
Dredging				
Bay Mud (soft)	1,473,000	CY	$5.56	$8,183
Bay Mud (hard)	181,000	CY	$13.89	2,514
Parking Lot, (soft)	123,000	CY	$4.02	494
Parking Lot, (hard)	15,000	CY	$15.00	225
Rock	7,000	CY	$39.42	276
Subtotal				$11,692
Other GNF				
E&D, Dredging	1	Job	LS	237
E&D, Parking Lot	1	Job	LS	57
SIOH, Dredging	1	Job	LS	541
Subtotal				$834
Additional O&M	11,210	CY	$3.79	$42
PED (Sunk Cost)				
Thru FY 95	1	Job	LS	$8,208
FY 96 (Est.)	1	Job	LS	895
Subtotal				$9,104
Total GNF				$22,956
Berthing Areas				
Parking Lot Disposal	96,000	CY	$4.02	$386
Dredging	23,000	CY	$5.56	128
Tipping Fee @ Montezuma	23,000	CY	$7.00	161
Subtotal				$675
LERRD				
Tipping Fee @ Montezuma	1,654,000	CY	$7.00	$11,578
Parking Lot				
Handling and Hauling	234,000	CY	$2.57	601
Rock Handling & Hauling	7,000	CY	$2.57	18
Berms	3,500	CY	$10.00	35
Drainage, Access Road	1	Job	LS	142
Design & Contingency	1	Job	LS	50
Lands & Damages	1	Job	LS	1,220
Real Estate & Const. Docum	1	Job	LS	83
Subtotal				$13,727
Aids to Navigation	1	Job	LS	$129
Total First Costs				$37,487

TABLE 4, (continued)
Preliminary Cost Estimates
ALTERNATIVE B
Bay Farm
($000)

Item	Quantity	Unit	Unit Price	Total Cost
Mob & Demob				
Clamshell Plant	1	Job	LS	$823
Dredging[1]				
Bay Mud, (soft)	1,597,000	CY	$4.43	$7,075
Bay Mud, (hard)	196,000	CY	$11.16	2,186
Bay Farm Disposal, Rock	7,000	CY	$24.84	174
Subtotal				$9,435
Other GNF				
Bay Farm Monitoring[2]	1	Job	LS	$3,516
E&D, Dredging	1	Job	LS	237
E&D, Bay Farm	1	Job	LS	67
SIOH, Dredging	1	Job	LS	618
Subtotal				$4,438
Additional O&M	11,210	CY	$3.79	$42
PED (Sunk Cost)				
Thru FY 95	1	Job	LS	$8,208
FY 96 (Est.)	1	Job	LS	895
Subtotal				$9,104
Total GNF				$23,842
Berthing Areas, Clam. Drdg.				
Bay Farm Disposal[1]	119,000	CY	$4.43	$527
Tipping Fee @ BF	119,000	CY	$2.00	238
Subtotal				$765
LERRD - Federal dredging				
Tipping Fee at Bay Farm	1,800,000	CY	$2.00	$3,600
Aids to Navigation	1	Job	LS	$129
Total First Costs				**$28,336**

TABLE 4, (continued)
Preliminary Cost Estimates
ALTERNATIVE C
Ocean/Graving Docks
($000)

Item	Quantity	Unit	Unit Price	Total Cost
Mob & Demob				
Clamshell Plant	1	Job	LS	$1,232
Dredging				
Ocean Disposal (soft)	1,473,000	CY	$9.72	$14,324
Ocean Disposal (hard)	181,000	CY	$15.02	2,719
GD, (soft)	123,000	CY	$3.40	418
GD, (hard)	15,000	CY	$11.73	176
Rock Excavation & Dspsl.	7,000	CY	$33.49	234
Subtotal				$17,872
Excess Material				
Off-Load, Mud & Rock	64,000	CY	$1.00	$64
Cont., Design, & Support	1	Job	LS	22
Decant/Dry, Mud	57,000	CY	$3.00	171
Cont., Design, & Support	1	Job	LS	59
Truck Haul	64,000	CY	$31.64	2,025
Material Testing	57,000	CY	$0.27	15
Subtotal				$2,356
Other GNF				
Ocean Monitoring	1	Job	LS	$1,115
E&D, Dredging	1	Job	LS	237
E&D, Ocean	1	Job	LS	10
E&D, GD	1	Job	LS	57
SIOH, Dredging	1	Job	LS	695
Subtotal				$2,114
Additional O&M	11,210	CY	$3.79	$42
PED (Sunk Cost)				
Thru FY 95	1	Job	LS	$8,208
FY 96 (Est.)	1	Job	LS	895
Subtotal				$9,104
Total GNF				$32,720
Berthing Areas, Clam. Drdg.				
GD Disposal	96,000	CY	$3.40	$326
Ocean Disposal	23,000	CY	$9.72	224
Subtotal				$550
LERRD				
Site Prep., Graving Docks				
Basin 1	1	Job	LS	$1,550
Basin 5	1	Job	LS	1,550
Basins 2&3	1	Job	LS	2,550
New Wharf @ Basin 5	1	Job	LS	1,290
Exist. Wharf @ Berth 6A	1	Job	LS	1,130
Const. Contract Documents	1	Job	LS	2,345
Real Estate Documents	1	Job	LS	65
Subtotal				$10,480
Aids to Navigation	1	Job	LS	$129
Total First Costs				$43,879

TABLE 4, (continued)
Preliminary Cost Estimates
ALTERNATIVE C1
Ocean/Montezuma
($000)

Item	Quantity	Unit	Unit Price	Total Cost
Mob & Demob				
Clamshell Plant	1	Job	LS	$1,232
Dredging				
Ocean Disposal (soft)	1,005,000	CY	$9.72	$9,769
Ocean Disposal (hard)	181,000	CY	$15.02	$2,719
Montezuma, (soft)	591,000	CY	$6.25	$3,694
Montezuma, (hard)	15,000	CY	$14.74	$221
Rock	7,000	CY	$47.52	$333
Subtotal				$16,735
Other GNF				
Ocean Monitoring	1	Job	LS	$1,115
E&D, Dredging	1	Job	LS	247
E&D, Ocean	1	Job	LS	10
SIOH, Dredging	1	Job	LS	695
Subtotal				$2,068
Additional O&M	11,210	CY	$3.79	$42
PED (Sunk Cost)				
Thru FY 95	1	Job	LS	$8,208
FY 96 (Est.)	1	Job	LS	895
Subtotal				$9,104
Total GNF				$29,181
Berthing Areas				
Mont. Dredge & Trans.	96,000	CY	$6.25	$600
Tipping Fee @ Mont.	96,000	CY	$7.00	672
Ocean Disposal	23,000	CY	$9.72	224
Subtotal				$1,496
Aids to Navigation	1	Job	LS	$129
LERRD - Federal dredging				
Tipping Fee @ Mont.	613,000	CY	$7.00	$4,291
Total First Costs				**$35,096**

TABLE 4, (continued)
Preliminary Cost Estimates
ALTERNATIVE C2
Ocean/Parking Lot
($000)

Item	Quantity	Unit	Unit Price	Total Cost
Mob & Demob	1	Job	LS	$1,416
Dredging				
Ocean Disposal, (soft)	1,473,000	CY	$9.72	$14,325
Ocean Disposal, (hard)	181,000	CY	$15.02	2,719
Parking Lot, (soft)	123,000	CY	$4.26	524
Parking Lot, (hard)	15,000	CY	$15.55	233
Rock	7,000	CY	$42.00	294
Subtotal				$18,095
Other GNF				
Ocean Monitoring	1	Job	LS	$1,115
E&D, Dredging	1	Job	LS	237
E&D, Ocean	1	Job	LS	10
E&D, Parking Lot	1	Job	LS	57
SIOH, Dredging	1	Job	LS	695
Handling and Hauling	234,000	CY	$2.57	601
Rock Handling & Hauling	7,000	CY	$2.57	18
Subtotal				$2,733
Additional O&M	11,210	CY	$3.79	$42
PED (Sunk Cost)				
Thru FY 95	1	Job	LS	$8,208
FY 96 (Est.)	1	Job	LS	895
Subtotal				$9,104
Total GNF				$31,390
Berthing Areas, Clam. Drdg.				
Parking Lot Disposal	96,000	CY	$4.26	$409
Ocean Disposal	23,000	CY	$9.72	224
Subtotal				$633
LERRD				
Parking Lot				
Berms	3,500	CY	$10.00	35
Drainage, Access Road	1	Job	LS	142
Design & Contingency	1	Job	LS	50
Lands & Damages	1	Job	LS	1,225
Real Estate & Const. Docs.	1	Job	LS	89
Subtotal				$1,541
Aids to Navigation	1	Job	LS	$129
Total First Costs				**$33,693**

TABLE 4, (continued)
Preliminary Cost Estimates
ALTERNATIVE D
Alcatraz/Graving Docks
($000)

Item	Quantity	Unit	Unit Price	Total Cost
Mob & Demob				
Clamshell Plant	1	Job	LS	$741
Hopper Plant	1	Job	LS	451
Subtotal				$1,192
Dredging				
Alcatraz, (soft, Hopper)	1,473,000	CY	$2.57	$3,786
Alcatraz, (hard, Clamshell)	181,000	CY	$11.16	2,019
GD, (soft, Clamshell)	123,000	CY	$3.15	387
GD, (hard, Clamshell)	15,000	CY	$11.16	167
Rock	7,000	CY	$30.91	216
Subtotal				$6,576
Excess Material				
Off-Load, Mud & Rock	64,000	CY	$1.00	$64
Cont., Design, & Support	1	Job	LS	22
Decant/Dry, Mud	57,000	CY	$3.00	171
Cont., Design, & Support	1	Job	LS	59
Truck Haul	64,000	CY	$31.64	2,025
Material Testing	57,000	CY	$0.27	15
Subtotal				$2,356
Other GNF				
E&D, Dredging	1	Job	LS	237
E&D, Alcatraz	1	Job	LS	10
E&D, GD	1	Job	LS	57
SIOH, Dredging	1	Job	LS	541
Subtotal				$845
Additional O&M	11,210	CY	$3.79	$42
PED (Sunk Cost)				
Thru FY 95	1	Job	LS	$8,208
FY 96 (Est.)	1	Job	LS	895
Subtotal				$9,104
Total GNF				$20,115
Berthing Areas, Clam. Drdg.				
GD Disposal	96,000	CY	$3.15	$302
Alcatraz Disposal	23,000	CY	$4.35	100
Subtotal				$402
LERRD				
Site Prep., Graving Docks				
Basin 1	1	Job	LS	$1,550
Basin 5	1	Job	LS	1,550
Basins 2&3	1	Job	LS	2,550
New Wharf @ Basin 5	1	Job	LS	1,290
Exist. Wharf @ Berth 6A	1	Job	LS	1,130
Const. Contract Documents	1	Job	LS	2,345
Real Estate Documents	1	Job	LS	65
Subtotal				$10,480
Aids to Navigation	1	Job	LS	$129
Total First Costs				**$31,127**

4.4. - Screening of Alternatives

4.4.1. - Least Cost Implementable Plan (LCIP)

Through an extensive public and agency review process, the three of the four disposal site combinations without wetland habitat restoration were eliminated from further consideration. Both the Alcatraz disposal site and disposal at the Bay Farm Island Borrow site were eliminated from further consideration. Both alternatives were determined to be to be unimplementable.

The Bay Farm Island borrow site alternative is inconsistent with existing San Francisco Bay Conservation and Development Commission (BCDC) policies. According to BCDC, the use of the Bay Farm Island borrow area site would represent a permanent fill in San Francisco Bay which is in direct conflict with the San Francisco Bay Plan. The San Francisco District conducted coordination specific to the consideration of the Bay Farm site. Subsequently, the Regional Water Quality Control Board (RWQCB) and BCDC expressed the need for detailed studies prior to consideration of the Bay Farm site as a candidate disposal site for the authorized project. Disposal of material dredged to maintain existing San Francisco Bay projects is given preference over new projects by the Corps at the Alcatraz Disposal site. Because the quantity of material from the proposed channel deepening is great and could jeopardize the ability of the site to handle the disposal of material from the existing projects at this time, the Alcatraz disposal site was also eliminated from further consideration.

After extensive analysis by the Port and the District, the Ocean/Graving Dock disposal alternative was also eliminated from consideration due to excessive costs. As a result of a preliminary design and cost estimate, the Port concluded that it could not raise the funds necessary to pay for the Non-Federal share of the total project cost. Consequently, the District analyzed four new disposal alternatives—Montezuma/Parking Lot, Ocean/Montezuma, Ocean/Parking Lot-Montezuma, and Ocean/Parking Lot—after submittal and HQUSACE review of the DGDM.

4.4.2. - Plan Including Habitat Restoration

Although dredged material suitable for unconfined aquatic disposal could be placed at a lower cost at the ocean disposal site, this material is a resource that could be used for habitat restoration at the Montezuma Wetlands site. Because this wetland demonstration project would provide significant habitat values, in addition to addressing commercial navigation needs, the alternative utilizing disposal at this site was further analyzed.

At present, however, use of the Montezuma Wetlands site is not cost effective. Using current estimates, this site would cost the local sponsor about $3.5 million more than the least cost plan. Consequently, the Montezuma Wetlands, Ocean/Parking Lot-Montezuma, and Montezuma/Parking Lot alternatives were eliminated from consideration. Moreover, due to a lengthy EIR/S and permit process, the Montezuma site will not be ready in time for an August 1996 construction start. As a result—barring significant changes to the project schedule and total project costs—the Ocean/Montezuma alternative was also eliminated from consideration.

4.5. - <u>Least Cost, Implementable Disposal Alternative</u>

With the elimination of the six other disposal sites, the least-cost disposal alternative is the Ocean/Parking Lot plan. Therefore, Alternative C2 is designated as the Least Cost Implementable Plan.

4.5.1. - Plan Description

The Least Cost Implementable Alternative is Alternative C, as described in Section 4.3.3.2.

4.5.2. - Project Costs

Section Six of this GDM presents the basis used for the development of project costs. The rounded first cost of the Least Cost, Implementable Disposal Alternative is $33,693,000. Details of this estimate are summarized on Table 3. The average annual cost of this alternative is $2,768,000 which includes maintenance costs and interest during construction.

4.5.3. - Project Benefits

The average annual navigation benefits for deepening the navigation channels to -38 feet MLLW are $4,574,000. These benefits are based on an 7⅝ percent interest rate and a 50-year period of economic evaluation. The derivation of these benefits is presented in the Appendix D.

4.5.4. - Cost Allocation

All costs of the Least Cost, Implementable Alternative, estimated to be $33,693,000 (rounded), are allocated to the navigational purpose.

4.5.5. - Cost Apportionment

All costs for the project are apportioned in accordance with WRDA 1986. Of the costs for general navigational features, 25 percent will be paid by the non-Federal sponsor, the City of Richmond, during the period of construction. An additional 10 percent of the cost for the general navigational features is normally required of the non-Federal sponsor over a period not to exceed 30 years. However, the value of lands, easements, rights-of-way, relocations, and disposal areas (LERRD's) is credited toward this payment over time. Consequently, $3,087,000 (10 percent of the cost of the general navigation features) less $2,161,000 (the LERRDs' value) results in a required additional payment—annualized over 30 years—of $926,000 based on current cost estimates. Furthermore, all necessary costs for lands, easements, rights-of-way, relocations, and dredged material disposal sites, for the project will be borne by the Port of Richmond. Based on current cost estimates, the total cost will be apportioned as follows: (1) $11,457,000 to the City of Richmond and (2) $22,236,000 to the Federal Government. See Table 5 for a detailed summary of the project cost apportionment.

TABLE 5

Richmond 38-Foot Project
Least Cost Implementable Plan
OCEAN/PARKING LOT
Cost Sharing, ($000)

30-Jan-96

Item	Quantity	Unit	Unit Price	Total Cost	%FED	Federal Cost	%Non-FED	Non-FED Cost
Mob & Demob								
Clamshell Plant	1	Job	LS	$1,416	75%	$1,062	25%	$354
Dredging								
Ocean Dspsl. (soft): -20 to -38 ft.	1,369,000	CY	$9.72	$13,313	75%	$9,985	25%	$3,328
Ocean Dspsl. (TB): 0 to -20 ft.	104,000	CY	$9.72	1,011	90%	910	10%	101
Ocean Disposal, (hard): -20 to -38	181,000	CY	$15.02	2,719	75%	2,039	25%	680
Parking Lot, (soft): -20 to -38 ft.	123,000	CY	$4.26	524	75%	393	25%	131
Parking Lot, (hard): -20 to -38 ft.	15,000	CY	$15.55	233	75%	175	25%	58
Rock	7,000	CY	$42.00	294	75%	221	25%	74
Subtotal				$18,095		$13,723		$4,372
Other GNF								
Ocean Monitoring	1	Job	LS	$1,115				
E&D, Dredging	1	Job	LS	237				
E&D, Ocean	1	Job	LS	10				
E&D, Parking Lot	1	Job	LS	57				
SIOH, Dredging	1	Job	LS	695				
Parking Lot: Handling & Hauling	234,000	CY	$2.57	601				
PL: Rock Handling & Hauling	7,000	CY	$2.57	18				
Subtotal				$2,733	75%	$2,050	25%	$683
Additional O&M	11,210	CY	$3.79	$42	100%	$42	0%	$0
PED (Sunk Cost)[1]								
Thru FY 95	1	Job	LS	$8,208	75%	$6,156	25%	$2,052
FY 96 (estimate)	1	Job	LS	895	75%	671	25%	224
Subtotal				$9,104		$6,828		$2,276
Total GNF[2]				$31,390		$23,705		$7,685
Berthing Areas, Clam. Dredging								
Parking Lot Disposal	96,000	CY	$4.26	$409				
Ocean Disposal	23,000	CY	$9.72	224				
Subtotal				$633	0%	$0	100%	$633
LERRD								
Parking Lot								
Berms	3,500	CY	$10.00	35				
Drainage, Access Road	1	Job	LS	142				
Design & Contingency	1	Job	LS	50				
Lands & Damages	1	Job	LS	1,225				
Real Estate & Const. Documents	1	Job	LS	89				
Subtotal				$1,541	0%	$0	100%	$1,541
Aids to Navigation	1	Job	LS	$129	100%	$129	0%	$0
Total First Costs				$33,693		$23,834		$9,859
10% of GNF				0		(3,139)		3,139
Subtotal				$33,693		20,695		12,998
Credit to LERRD				0		1,541		(1,541)
Total Cost Sharing				**$33,693**	**66%**	**$22,236**	**34%**	**$11,457**

4.6. - <u>Evaluation Criteria</u>

The seven disposal plans were tested against four specified criteria. The following paragraphs define the criteria and how the alternatives relate to the criteria.

4.6.1. - Completeness

Completeness is a determination of whether the plan includes all elements necessary to achieve project objectives. Alternative C2 meets this criteria.

4.6.2. - Effectiveness

Effectiveness is defined as a measure of the extent to which a plan achieves its objectives. All seven plans are equally effective in addressing the navigation problems at the Port of Richmond.

4.6.3. - Efficiency

Efficiency of a plan is its ability to achieve the planning objectives and the National Economic Development (NED) outputs in the least costly manner. Alternative C2 is the most efficient plan in meeting the Port's navigation improvement objectives. While there may be less costly disposal sites within San Francisco Bay, none with the required capacity have been identified for use at this time.

4.6.4. - Acceptability

Acceptability is defined as acceptance of the plan by the local sponsor and the concerned public. The Least Cost, Implementable Alternative has support from the City of Richmond and the public because it is the least cost method for realizing the navigation benefits afforded by the project.

4.7. - <u>Plan Selection</u>

4.7.1. - Designation of the NED Plan

The Least Cost, Implementable Alternative is designated as the NED Plan for the purpose of plan selection.

4.7.2. - Confirmation of Channel Optimization

Average annual project costs in one-foot increments are shown for channel deepening in Table 9 of the Economics Appendix. These costs are based on the Least Cost, Implementable Alternative. Average annual project benefits in one-foot increments are also shown on this table for channel deepening. These benefits were determined using the same procedures that are outlined in section six. The annual net benefits, the difference between the average annual project benefits and average annual project costs, are shown in Section 6.1, which indicates

that maximum net benefits accrue to channel depth of -38 feet MLLW.

4.7.3. - Plan Selection

Because the Least Cost, Implementable Alternative has wide support, provides significant navigational improvements, and maximizes net economic benefits, it is selected for construction. All of the estimates and cost apportionments in this report are based on a selected channel depth of -38 feet MLLW.

5.0 Environmental Concerns

The sediment quality within Richmond Harbor will impact disposal site selection. Other environmental impacts may include water quality, biological resources, air quality, and noise. The proposed project will require State participation from the Regional Water Quality Control Board (RWQCB) and the Bay Conservation and Development Commission (BCDC).

5.1. - Sediment Quality

5.1.1. - Sampling Collection and Testing

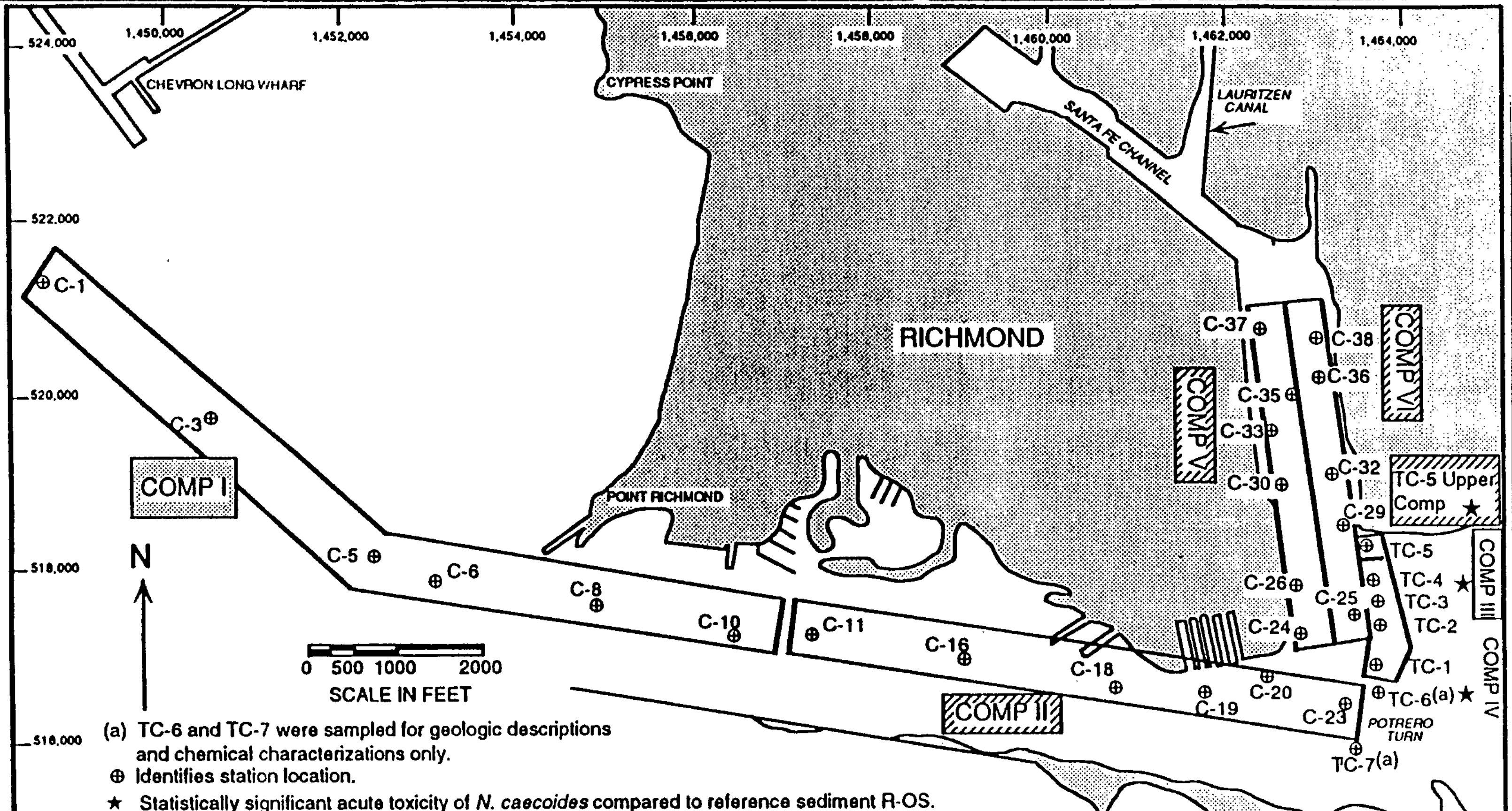
During three sampling episodes, a total of 76 sediment samples were collected. Sixty-six (66) of these were composited into 15 composite samples for physical, chemical, toxicity, and bioaccumulation testing (see Figure 16). Toxicity test species were the amphipod *Rhepoxinius abronius*, the polychaete worm *Nephtys caecoides*, and the clam *Macoma nasuta*. Bioaccumulation test species were *M. nasuta*, *N. caecoides* and the polychaete *Nereis virens*. An additional 10 samples from the turning basin area were tested for *R. abronius* toxicity and physical and chemical characteristics. Three of the composites lay outside the final turning basin area, and samples were further combined for the purpose of determining disposal suitability, so that these determinations were made for 12 composites representing the entire proposed dredging area. The objective of the testing was to compare sediment chemistry, acute toxicity, and bioaccumulation results of Richmond Harbor sediments to each of the disposal site alternatives. The disposal site alternatives were: the Deep Off-Shelf Area, the Bay Farm Borrow Area, and Alcatraz Environs Area.

5.1.2. - Bioaccumulation

The evaluation of tissue bioaccumulation was performed for Richmond Harbor sediments relative to the Deep Off-Shelf Area, the Bay Farm Borrow Area, and the Alcatraz site. The results included complete tissue chemistry and quality control results. The benthic organisms were exposed to solid-phase sediment treatments from Richmond Harbor over 28 days. The test was designed to evaluate the bioaccumulation potential of chemical contaminants from each sediment treatment. The tissues of *M. nasuta*, *N. virens*, and *N. caecoides* were analyzed for approximately 50 contaminants of concern, including PAHs, pesticides, PCBs as aroclors, metals, and butyltins (tri- and di-).

5.1.3. - Testing Results

Mortality of *R. abronius* exceeded limiting permissible concentration (LPC) criteria for two test composites compared with the ocean reference site, three test composites compared with the Bay Farm reference site, and seven test composites compared with the Alcatraz environs reference site. Mortality of *N. caecoides* exceeded LPC criteria for seven test composites compared with the ocean reference site, two test composites compared with the Bay Farm reference site, and five test composites compared with the Alcatraz reference site. *M. nasuta* did not show mortality significantly greater than any of the reference sites.



(a) TC-6 and TC-7 were sampled for geologic descriptions and chemical characterizations only.

⊕ Identifies station location.

★ Statistically significant acute toxicity of *N. caecoides* compared to reference sediment R-OS.

COMPOSITING SCHEME

COMP I: C-1, C-3, C-5, C-6, C-8, C-10
COMP II: C-11, C-16, C-18, C-19, C-20, C-23
COMP III: Upper part of TC-1, TC-2, TC-3, TC-4
TC-5 Upper Comp: Upper part of TC-5
COMP IV: Lower part of TC-1, TC-2, TC-3, TC-4, TC-5
COMP V: C-24, C-26, C-30, C-33, C-35, C-37
COMP VI: C-25, C-29, C-32, C-36, C-38

☐ Indicates bioaccumulation ≥2 times reference sediment R-OS.
▨ Indicates bioaccumulation ≥5 times reference sediment R-OS.
▨ Indicates bioaccumulation ≥10 times reference sediment R-OS.

RICHMOND HARBOR

Sediment Treatments with Acute Toxicity and/or Bioaccumulation of at Least One Contaminant in the Tissues of at Least One Species (*M. nasuta* or *N. caecoides*) at ≥2, ≥5, and ≥10 Times the Level Found in Tissues Exposed to the Reference Sediment R-OS

Source:Battelle PNL-8958 December 1993

CONTRA COSTA COUNTY	CALIFORNIA
RICHMOND HARBOR 38-FOOT PROJECT PHASE I	
SEDIMENT MAP A	
IN SHEET	SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E	
DRAWN:	FILE NO.
TRACED:	TO ACCOMPANY REPORT
CHECKED:	DATED

FIGURE 16

In the bioaccumulation tests, no test species bioaccumulated any chemical contaminants to levels exceeding FDA action levels. However, many test samples showed bioaccumation of contaminants at significantly higher levels than reference sediments, for all three test species. The ratio of test tissue concentration to reference tissue concentration ranged from less than 2 to greater than 10. The largest ratios were observed for DDD, PAHs, and PCBs; smaller ratios were noted for metals and organotins. M. nasuta tended to bioaccumulate contaminants more readily than the two polychaete species. In general, test sediments showed significant bioaccumulation more frequently in comparison to the ocean reference site than in comparison to the two in-Bay sites.

5.1.4 - Conclusions

Considering all of the testing results, eight of the 12 composites were determined by the EPA and Corps to be suitable for both ocean and in-Bay unconfined disposal, with the exception of two subcomposites within one of the eight composites. The other four composites, collected from the Santa Fe Channel and inner harbor berthing areas, were found unsuitable for open-water disposal. The suitable composites represent a dredging volume of approximately 1.68 MCY. The unsuitable composites represent a dredging volume of approximately 234,000 CY.

5.2. - Water Quality

5.2.1. - Introduction

In 1974 the State Water Resources Control Board (SWRCB) adopted the "Water Quality Control Policy for the Enclosed Bays and Estuaries of California" under SWRCB Resolution Number 74-43. The purpose of this policy is to prevent water quality degradation and to protect the beneficial uses of bay and estuaries in California by establishing water quality principles, effluent quality requirements, and prohibitions governing the disposal of wastes into these waters. The Board determined that the discharge of municipal waste waters and industrial process waters should be phased out at the earliest practicable date. Exceptions to this provision are only allowed if the Board finds that the waste water in question is consistently treated and discharged in such a manner that it enhances the quality of the receiving waters above what would occur in the absence of the discharge.

Water quality criteria were developed by the EPA to protect approximately 95 percent of the organisms in the aquatic environment based upon acute, chronic, and bioaccumulation testing of species at different trophic levels. These criteria were developed from comprehensive species-specific acute, chronic, and bioaccumulation databases. Each database was derived from studies of estuarine species and single contaminants. Finally, these criteria were used as toxicological estimates for aquatic chemical concentrations that are protective of marine life.

5.2.2. - Water Column Effects

Determination of compliance for water column effects involves deciding whether the

concentration of dissolved plus suspended contaminants, after allowance for initial mixing, is less than the LPC. For water column effects, two LPC's are defined: the applicable water quality criteria (WQC); and the water column toxicity LPC, defined as 1 percent of the lowest median lethal concentration (LC50) of dredged material in suspended particulate phase (SPP) toxicity tests. For the ocean site, the applicable WQC are the federal acute marine WQC; for in-Bay sites, the state water quality standards apply (California has proposed to adopt the federal WQC, with a few exceptions).

For the ocean site, initial mixing is defined as 4 hours of mixing or the boundary of the disposal site. The state defines the mixing zone for in-Bay and other inland sites, usually as the boundary of the disposal site. If mortality of at least 50 percent is not observed in the SPP tests (such as for the Richmond material), an LC50 cannot be determined. In such cases, a conservative (protective) approach is to use the lowest EC50 (median effective concentration from non-lethal bioassay tests) in lieu of the LC50 to set the LPC. This was done for the Richmond project; the lowest LPC was 0.224 percent dredged material based on an EC50 of 22.4 percent.

The Corps used the Implementation Manual's DIFID module of the STFATE model to simulate disposal at the three aquatic disposal sites and evaluate compliance with the LPC. This modeling showed compliance with the WQC LPC at all three sites and compliance with the water column toxicity LPC at the ocean and Bay Farm sites. For the Alcatraz site, the model indicated that the water column toxicity LPC would be exceeded at the site boundary for most sediment composites and under most current conditions used in the modeling. It should be kept in mind that the water column toxicity LPC is based on the lowest EC50 rather than LC50, as discussed above, and so is perhaps unrealistically low. In addition, the LPC exceedance occurred under peak current velocities, but not on slack tide. Monitoring conducted for disposal of dredged material at the Alcatraz site has shown much lower concentrations of dredged material at the site boundary than predicted by the model. Therefore, should disposal be proposed for the Alcatraz site, it is likely that conditions can be identified under which a reasonable LPC could be met.

5.2.3. - Mitigation

Dredged material determined by the EPA to be unsuitable for aquatic or wetland disposal will be placed at the Point Potrero parking lot.

5.3. - Biological Resources and Special Surveys

5.3.1. - Eelgrass and Benthic Organisms Surveys

The Eelgrass Survey team used fathometer location techniques, bounce dive frequency, and density identification. Eelgrass was found along the training wall, Brooks Island, and north of the turning basin area. There was "patchy" eelgrass distribution throughout the study area. Specifically, there was eelgrass growth a minimum of 50 feet from the top of slope of the new channel cut near Brooks Island. In addition, eelgrass in the vicinity of the turning basin was a few hundred feet from the top of the slope for the recommended design.

The Benthic Organism Survey team took 24 Van Veen grab samples from the channel bottom, channel slope, and the shallows above the new turning basin. Three sub-samples were collected from each of the Van Veen grab samples. The laboratory team removed the animal and live plant material from the preserved samples. Then they sorted the samples into major taxonomic categories and identified each organism to the lowest taxonomic level practical. A statistical analysis was performed to determine any changes in benthic communities at the three sample areas.

The results of the survey indicate: (a) There is little difference in community descriptors among the channel, side slope, and shallows areas; (b) The total number of species were greatest in the shallows area; (c) Some individual species exhibited considerably different abundance patterns among the three areas; (d) Densities were the lowest in the shallow area; and (e) Densities in the Richmond Harbor sampling area were depressed compared to results from the sampling for Oakland Inner Harbor. A 1961 study by M. L. Jones supports the low density results.

5.3.2. - Endangered and Threatened Species

Birds among the listed endangered species which may occur in the project area are the brown pelican, peregrine falcon, and least tern. The pelican is commonly observed during the non-breeding months (June to December) foraging for fish around the piers along the inner harbor and by the Brooks Island training wall. Least tern are normally present during the April-to-September breeding season. Should the least terns return to this area, they would be expected to sight feed nearby on small, surface-schooling fish.

A few peregrine falcon nests have been verified on the Bay Bridge, several miles from the project area. This breed is predacious and known to feed up to several miles from its nest on various prey, including waterbirds and shorebirds. Their breeding season extends from early spring to early summer; however, they are present in greater numbers in the San Francisco Bay area during the winter.

During dredging activities, the increase in turbidity may disrupt foraging by waterbirds which use sight to locate their prey. The U.S. Fish and Wildlife Service (FWS) has jurisdiction over endangered and threatened bird species.

Fish which may be in the area include the "winter-run" race of chinook salmon. This fish is a Federally-listed threatened species which is under the jurisdiction of the National Marine Fisheries Service (NMFS) of the National Oceanic and Atomospheric Administration. This species is expected to be in the central Bay as adults from about December through April during their upstream spawning migration, and again as juvenile smolts passing through the area from late October to late May as they migrate to the ocean. The project area is situated along the margin of the likely routes of the upstream and downstream migration. Similarly, adult longfin smelt, a Federal candidate species under FWS jurisdiction, migrates though the area between December and August. This species has declined substantially in recent years and is among those listed in a recent petition to list the Delta as an endangered ecoregion.

5.3.3. - Mitigation

Mitigation needs have been determined. The eelgrass beds are not within dredging area; therefore, no monitoring will be conducted for the eelgrass. Proper justification for monitoring could not be found. Consequently, an eel grass survey will not be conducted for this project. While there is a potential adverse impact, no impacts to the eel grass areas are expected..

In addition, the depressed count of benthic organisms and the relatively small area of shallows proposed to be dredged compared to the remaining shallow area in the harbor vicinity will not require mitigation for habitat loss. The presence of endangered bird species will not require adjustments in the scheduling of dredging at certain reaches of the proposed project. The winter-run chinook salmon (adult and juvenile) migration paths and depths have been reviewed and it was determined that there will be no effects by the barge traffic from the proposed project area to the ocean site and other disposal alternatives.

Furthermore, the following was agreed upon to comply with Fish & Game's (F&G) proposed dredging window from 1 December to 1 March during the herring spawn each year. There are two levels of compliance: (1) a "zone of avoidance"—delineated by the District—around the eel grass areas in the Inner Harbor and Potrero Reach Channels will be included in the project specifications and used to develop a construction schedule; and (2) if dredging needs to be done in the "zone" during the 90-day window, the contractor will provide a written request and justification to the District and F&G for approval; and if the request is approved, the District will monitor for spawns from the dredge and disallow any dredging within 200 meters of a spawn for at least 14 days.

5.4. - Air Quality

5.4.1. - Introduction

Air quality at a given location can be described by the concentrations of various pollutants in the atmosphere. Units of concentration are generally expressed in parts per million (ppm) or micrograms per cubic meter (ug/m^3). The significance of a pollutant concentration is determined by comparing it to the concentration of an appropriate federal or state ambient air quality standard or both. The pollutants of main concern that are considered in the analysis include ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), and particulate matter smaller than 10 microns in diameter (PM_{10}).

5.4.2. - Methodology

A determination of project consistency with the Bay Area Clean Air Plan (CAP) requires evaluation if the proposed action will interfere with the attainment strategy outlined in the CAP. The CAP emission inventory is outlined in the SEIS/EIR document.

Identifying the Region of Influence (ROI) for air quality requires knowledge of the types of pollutants being emitted, the emission rates and release parameters of the pollutant source

(e.g., release temperature, area of release, release height, etc.), the source proximity to other pollutant sources, and local and regional meteorological conditions. The ROI for emissions of inert pollutants (all pollutants other than O_3 and its precursors) is generally limited to a few miles downwind from a source. Thus, for the emission of inert pollutants from project-related activities, the ROI is limited to the immediate coastal areas of Contra Costa, Marin, and San Francisco Counties.

5.4.3. - Regional Analysis/Conformity Determination

The project dredging area and alternative disposal sites are located in the San Francisco Bay Area Air Basin (SFBAAB). The SFBAAB is comprised of nine counties, including Santa Clara, San Mateo, San Francisco, Marin, Napa, Contra Costa, Alameda, the southeast portion of Sonoma, and the southwest portion of Solano counties. The SFBAAB covers an area of approximately 5,530 square miles. Air quality in the immediate project area and surrounding regional environment of the SFBAAB will be affected by emissions from: (1) equipment associated with the dredging and disposal activities, and (2) employee commute vehicles.

Because disposal sites are scattered throughout the region and are several miles distant from the Richmond Harbor site, project emissions will be spread over much of the Bay Area. Additionally, because most of the project sources will be from mobile equipment, pollutant impacts will not be large enough in a localized area to exceed ambient air quality standards. However, dredging and disposal emissions may exceed BAAQMD significance thresholds. As a result, two mitigation measures were identified.

5.4.4. - Mitigation

The proposed dredging and disposal activities will occur for approximately 10 to 15 months. The main combustive emission for the proposed action will be from diesel-powered clamshell dredges and tugboats that assist dredges and transport dredged material. Disposal activities at the wetland and parking lot sites will also include usage of pumps to remove dredged material from the barges, and earth-moving equipment such as bulldozers, compactors, and graders. Some emissions associated with employee commuting will also occur.

Hence, two mitigation measures were identified in the SEIR to reduce project emissions to insignificance: (1) retard injection timing of diesel-powered equipment of No_x control and (2) use reformulated diesel fuel to reduce TOG/ROG and SO_2.

5.5. - <u>Noise</u>

There are no federal regulations or state laws directly applicable to the noise assessment for this project. The California Environmental Quality Act (CEQA) includes qualitative guidelines for determining the significance of adverse environmental noise impacts. In addition, the Noise Element of the City of Richmond's General Plan sets forth policies and programs to control noise within the city, including zoning ordinances that contain noise standards applicable to the proposed project.

5.5.1. - Mitigation

The potential affect on residents of Point Richmond resulting from dredging noise in the Potrero Reach was determined to be insignificant except in two small areas in the Potrero Reach Channel affecting approximately 75,000 CY of dredging. No nighttime dredging will be allowed in these areas.

5.6. - Final SEIS/EIR

The SEIS/EIR analyzed the impacts associated with the proposed deepening of the Richmond Harbor. This document fulfills the requirements of the National Environmental Policy Act (NEPA) to support construction of the Richmond Harbor Proposed Project.

5.7. - Water Quality Certification

The Section 404(b)(1) Evaluation of the Clean Water Act (CWA) is being prepared and is included as Appendix C in the SEIS/EIR. The Regional Water Quality Control Board will review the SEIS/EIR and, if accepted, will provide either a water quality certificate or a waiver statement of no impacts.

5.8. - BCDC Determination of Consistency

The consistency results should be provided after review by the state agencies involved. The Bay Conservation and Development Commission, if they concur with the Consistency Determination, will provide the Port of Richmond its dredging permit.

5.9. - United Heckathorn Superfund Site

The United Heckathorn Superfund Site includes clean up of both the Lauritzen Channel which branches off the Santa Fe Channel and the Parr-Rich Canal located at the northeast corner of the Inner Harbor Channel. The site was used between 1947 and 1966 to formulate and package pesticides. Significant levels of contamination were found in the upland and embankment areas of the site. Although over 99 percent of the pesticides have been removed from the upland portion since 1990, contaminated marine sediment still remains. The Lauritzen Channel was last dredged for berth maintenance in 1985.

Based on the EPA's most optimistic schedule, approximately 65,000 CY of contaminated sediment will be dredged from both locations between April and July of 1996. To prevent transport of contaminated material to the Federal Channel, silt curtains will be erected across the mouth of each channel prior to dredging. Moreover, to promote the return of flora and fauna to the area, a ½-foot layer of clean material will be placed after the contaminated sediment is removed. Finally, the EPA has determined that no adverse effects will occur if the Richmond Harbor Deepening Project occurred prior to or simultaneously with the EPA cleanup.

If, however, cleanup of the United Heckathorn Superfund Site occurs after the Richmond

Project, there is a very small chance that contaminated material will migrate to the clean, deepened Federal Channel. In the Port's, District's, and EPA's opinion, if the Superfund site cleanup is delayed, the Richmond Project should continue as scheduled for the following reasons:

(a) Deepening of the Federal Channel will not cause side slope failure at the mouth of either the Lauritzen Channel or Parr-Rich Canal;

(b) The tidal currents are weak and the tidal prism will not be changed by deepening project and therefore, migration of contaminated sediment from the Superfund site is highly unlikely;

(c) Storm drain fallout no longer exists and the upland source has been cleared;

(d) Testing will be done prior to O&M dredging to assure that contaminated material from the deepened Federal channel is not placed at the Alcatraz disposal site.

In the unlikely event that contaminated material from the Superfund site does migrate in the deepened Federal Channel, the local sponsor would be responsible for the disposal of the area's O&M material at an upland site. The Port could, of course, pursue United Heckathorn to pay for this potential additional cost.

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6.0 Project Economics

6.1. - Benefits

The economic evaluation in Appendix D details the analyses used to derive the project benefits associated with deepening the Richmond Inner Harbor Channels from -35 feet MLLW to alternate depths from -36 to -40 feet MLLW. Project benefits are derived by comparing the differences in costs of operating vessels in the Port of Richmond with and without the recommended plan. The benefit calculations are discussed primarily for the 38-foot project, the NED project, to simplify the presentations. However, similar calculations were performed for the other alternatives and are shown in Appendix D.

An analysis was made of movements in Richmond Harbor during 1992. Each movement was identified by ship, shipping route, commodity, tonnage handled, deadweight tonnages (loaded and unloaded), and actual drafts. Using this information and projecting future cargo demands, an estimate was made of the requirement for larger, more efficient ships to meet demand. Growth was forecasted to increase for all commodities throughout the 50-year life of the project. Total tonnage for the affected commodities is expected to increase from 1.9 million tons in 1993 to 7.2 million tons in 2045.

Under the without-project condition, channel depth limitations require light-loading of vessels, prevent larger ships from entering, and cause delays while ships wait for high tide. These conditions will worsen given the projected tonnages. A deeper harbor allows shipping companies to increase ship size, optimize their schedules and increase the tonnage carried, and eliminate light-loading practices which would result in lower operating costs. Moreover, a deeper harbor will reduce the frequency and length of tidal delays.

6.1.1. - Net Benefits

The total net benefits associated with the 38-foot project are $1.81 million. The average annual benefits and costs for each project depth are listed below (1995 Price Level, 7⅝ %).

Table 6
Benefits Summary

Project Depth	*Avg. Annual Benefits*	*Avg. Annual Costs*	*Net Benefits*
36 Feet	$3,286,000	$2,015,000	$1,271,000
37 Feet	4,158,000	2,588,000	1,570,000
38 Feet	**4,574,000**	**2,762,000**	**1,806,000**
39 Feet	5,038,000	3,664,000	1,374,000
40 Feet	5,465,000	4,213,000	1,252,000

6.2. - <u>Cost Estimates</u>

6.2.1. - Baseline Cost Estimates

A full MCACES Baseline Cost Estimate was prepared for the Least Cost Implementable Plan (Alternative C2 in Section 4) and will be forwarded to HQUSACE for review and approval. Baseline Cost Estimates for the remaining disposal alternatives are in Appendix E. See Table 7 for a summary of the MCACES Baseline Cost Estimate and Appendix E for Contingency Footnotes and Basis of Cost.

6.2.2. - Cost Estimate Assumptions

a. Project Description: The project consists of channel deepening in the Richmond Harbor. Each channel reach will be deepened to a project depth of -38 feet mean lower low water. In addition, a 1-foot tolerance (overdepth) below project depth will be dredged in areas of soft material including up to an additional 1-foot tolerance in areas of hard material. A total of approximately 1.91 MCY of material will be dredged. Of the total, about 1.47 MCY of soft material and 181,000 CY of hard material will be dredged and deposited at an EPA approved Ocean disposal site. The remaining material, 219,000 CY of unsuitable soft material, 15,000 CY of unsuitable hard material, and 7,000 CY of underwater rock will be dredged and placed in the Port's parking lot, an upland disposal site.

b. Pricing is based on January 1996 price levels. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the most recent MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (increased by 3.0 percent over the January 1995 estimates). This estimate assumes that the Contractor will be working 24 hours a day, 7 days a week.

c. The San Francisco District obtained real estate costs for the Parking Lot disposal area from the Sacramento District, Real Estate Division. Site preparation costs for the Parking Lot—which were provided by the local sponsor and reviewed by the Corps—includes off-loading, hauling, grading, berms, a peripheral access road, and contingencies.

d. This estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract. The prime contractor will execute all dredging, hauling and disposal operations.

e. Mobilization and demobilization for plant and equipment are based on the preparation, transfer, setup and removal of plant and equipment required. It is assumed that mobilization and demobilization of all equipment can be performed in 14 days.

f. Dredging will be done by a 20 CY clamshell dredge. The ocean disposal work will use 6-4,000 CY bottom dump scows, 5-2,300 HP hauling tugs, 1-850 HP support tug, and other support equipment. The dredge/haul production rate is estimated to be 360 CY per hour for soft material and 140 CY per hour for hard material (working 730 hours per month). A 20 CY clamshell dredge, 3-4,000 CY bottom dump scows, 2-1 200 HP hauling tugs, 1-850 HP

support tug, and other support equipment will execute dredging and disposal at the Parking Lot disposal site. A second clamshell plant will unload the material. The dredge/haul production rate is approximately 620 CY per hour for soft material and 140 CY per hour for hard material (again, working 730 hours per month).

For all dredging and disposal operations, the number of scows required was determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. Barges will be filled to 80 percent capacity and no overflow will be allowed. The average tugboat speed for round trips is assumed to be 6 knots.

g. Underwater rock will be excavated using the same clamshell plant and equipment with a 9 CY bucket and a second clamshell plant would be used to unload the rock. The production rate will be approximately 70 CY per hour.

h. Hauling distance from the dredge site to the Ocean disposal area is approximately 72 miles. Hauling distance from the dredge site to the Parking Lot disposal site is approximately 1 mile.

i. Construction Time. The project *can* be completed in 9 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

TABLE 7

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
OCEAN/PARKING LOT ALTERNATIVE C2
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
01------	LANDS & DAMAGES	$89,100	$0	$89,100	$2,138 *	$91,238
12------	NAVIGATION, PORTS & HARBORS	$17,842,246	$2,912,663	$20,754,909	$622,647	$21,377,556
30------	PLANNING, ENGINEERING & DESIGN	$9,~~503~~,850 406	$0	$9,~~503~~,850 406	$285,116	$9,~~788~~,966 691
31------	CONSTRUCTION MANAGEMENT	$695,250	$0	$695,250	$20,858	$716,108
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$28,~~167~~,394 070	$2,918,205	~~$31,085,599~~ 30,988,599	$932,033	~~$32,017,632~~ 31,920,632
NON-FEDERAL COSTS						
01------	LANDS & DAMAGES	$1,225,000	$0	$1,225,000	$29,400 *	$1,254,400
12------	NAVIGATION, PORTS & HARBORS	$1,397,133	$82,569	$1,479,702	$44,391	$1,524,093
NON-FEDERAL COSTS, TOTAL		$2,622,133	$82,569	$2,704,702	$73,791	$2,778,493
FEDERAL & NON-FEDERAL COSTS, TOTAL		$30,~~789~~,527 692	$3,000,774	$33,~~790~~,301 693	$1,005,824	$34,~~796~~,125 699

*Real Estate costs are escalated to the Certification date for LERRDS, 7/96.

TABLE 7 (continued)

Thu 25 Jan 1996
Eff. Date 01/01/96

U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/PARKING LOT ALT C2						
FEDERAL COSTS						
01------ LANDS AND DAMAGES, PARKING LOT						
Federal Review	1.00 JOB	89,100	0	0	89,100	89100.00
12------ NAVIGATION, PORTS & HARBORS						
1202---- HARBORS						
120201-- Mobilization & Demobilization, Contingency 25%, Reason 1/						
Mob & Demob, Clamshell	1.00 JOB	1,100,000	33,000	283,250	1,416,250	1416250
120215-- Clamshell Dredging, Contingency 15%, Reason 2/						
SOFT DREDGING & OCEAN DISPOSAL Dredging, Clamshell	1473000 CY	12,093,330	362,800	1,868,420	14,324,550	9.72
SOFT DREDGING & PARKING LOT DISP Dredging, Clamshell	123000.00 CY	442,800	13,284	68,413	524,497	4.26
HARD DREDGING & OCEAN DISPOSAL Dredging, Clamshell	181000.00 CY	2,295,080	68,852	354,590	2,718,522	15.02
HARD DREDGING & PARKING LOT DISP Dredging, Clamshell	15000.00 CY	196,950	5,909	30,429	233,287	15.55
120215-- Clamshell Dredging, Contingency 25%, Reason 5/						
Rock Excavation & Disposal	7000.00 CY	228,340	6,850	58,798	293,988	42.00
120299-- Associated General Items, Contingency 25%, Reasons 3/, 4/						
AIDS TO NAVIGATION	1.00 JOB	100,000	3,000	25,750	128,750	128750.00
OCEAN MONITORING	1.00 JOB	892,051	0	223,013	1,115,063	1115063
30------ PLANNING, ENGINEERING & DESIGN						
E&D						
E&D, Dredging	1.00 JOB	230,000	6,900	0	236,900	236900.00
E&D, Ocean Site	1.00 JOB	10,000	300	0	10,300	10300.00
E&D, Parking Lot	1.00 JOB	55,000	1,650	0	56,650	56650.00
E&D, Sunk	1.00 JOB	~~9,200,000~~ 9,103,000	0	0	~~9,200,000~~ 9,103,000	9200000
TOTAL E&D	1.00 JOB	9,~~495~~,000 398	8,850	0	9,~~503~~,850 406	9503850
31------ CONSTRUCTION MANAGEMENT (S&I)						
SIOH, Dredging	9.00 MO	675,000	20,250	0	695,250	77250.00
OPERATIONS & MAINTENANCE	11210.00 CY	35,872	1,076	5,542	42,490	3.79
TOTAL FEDERAL COSTS	1.00 JOB	27,~~643~~,523 546	523,871	2,918,203	~~31,085,597~~ 30,988,597	31085597

TABLE 7 (continued)

Thu 25 Jan 1996
Eff. Date 01/01/96

U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COS
OCEAN/PARKING LOT ALT C2							
NON-FEDERAL COSTS							
01------ LANDS AND DAMAGES, PARKING LOT							
Non-Federal Review	1.00	JOB	15,000	0	0	15,000	1500
Lands (LERRDS)	1.00	JOB	1,210,000	0	0	1,210,000	121000
01------ TOTAL LANDS AND DAMAGES, PARKING LOT	1.00	JOB	1,225,000	0	0	1,225,000	122500
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120215-- Clamshell Dredging, Contingency 15%, Reason 2/							
DREDGING & OCEAN DISPOSAL							
6C, 6D, 7							
Dredging, Clamshell	23000.00	CY	188,830	5,665	29,174	223,669	9.7
DREDGING & PARKING LOT DISPOSAL							
TERM 2							
Dredging, Clamshell	22000.00	CY	79,200	2,376	12,236	93,812	4.2
TERM 3							
Dredging, Clamshell	15000.00	CY	54,000	1,620	8,343	63,963	4.2
ARCO							
Dredging, Clamshell	15000.00	CY	54,000	1,620	8,343	63,963	4.2
GATX							
Dredging, Clamshell	15000.00	CY	54,000	1,620	8,343	63,963	4.2
GOLD BOND							
Dredging, Clamshell	5000.00	CY	18,000	540	2,781	21,321	4.2
LEVIN							
Dredging, Clamshell	11000.00	CY	39,600	1,188	6,118	46,906	4.2
TEXACO							
Dredging, Clamshell	5000.00	CY	18,000	540	2,781	21,321	4.2
TIME OIL							
Dredging, Clamshell	5000.00	CY	18,000	540	2,781	21,321	4.2
UNOCAL							
Dredging, Clamshell	3000.00	CY	10,800	324	1,669	12,793	4.2
TOTAL DREDGING & PARKING LOT DISPOSAL	96000.00	CY	345,600	10,368	53,395	409,363	4.2

TABLE 7 (continued)

Thu 25 Jan 1996
Eff. Date 01/01/96

U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/PARKING LOT ALT C2							
NON-FEDERAL COSTS							
120220-- Disposal Areas							
12022002 Site Work							
HANDLING, HAULING AND DRYING							
Handling and Hauling	234000.00	CY	601,380	0	0	601,380	2.57
Rock Handling and Hauling	7000.00	CY	17,990	0	0	17,990	2.57
TOTAL HANDLING, HAULING AND DRYING	1.00	JOB	619,370	0	0	619,370	619370
PARKING LOT SITE PREPARATION							
Berms	3500.00	CY	35,000	0	0	35,000	10.00
Drainage	1.00	JOB	40,000	0	0	40,000	40000.00
Access Road	1.00	JOB	102,000	0	0	102,000	102000.00
Design, 7%	1.00	JOB	12,400	0	0	12,400	12400.00
Contingencies, 20%	1.00	JOB	37,900	0	0	37,900	37900.00
TOTAL PARKING LOT SITE PREPARATION	1.00	JOB	227,300	0	0	227,300	227300.00
TOTAL NON-FEDERAL COSTS	1.00	JOB	2,606,100	16,033	82,569	2,704,702	2704702
TOTAL OCEAN/PARKING LOT ALT C2	1.00	JOB	30,~~249~~,623 152	539,904	3,000,772	33,~~790~~,299 693	33790299

6.3. - Operation and Maintenance

6.3.1 - Federal

Historical maintenance dredging records from 1975 through 1984 indicate that an average of 425,000 CY of material was clamshell dredged annually from the Richmond Inner Harbor, including the Santa Fe Channel (since 1984, the Santa Fe Channel has not been dredged). Annual maintenance dredging for the deepened Richmond Harbor will increase by approximately 11,210 CY (see Table 8 below). This calculation is based on the equation:

$$Z_2 = Z_1[(d_2)^2/(d_1)^2 * A_2/A_1]$$

Where Z = annual dredging quantity, d = depth, A = channel bottom surface area, and the subscripts 1 and 2 apply, respectively, to the existing and proposed conditions.

Table 8
O&M Dredging Estimate

Reach	*Channel Bottom Area*		*Channel Depth*		*Annual Maintenance*	
	Existing (SF)	Project (SF)	Existing (FT)	Project (FT)	Existing (CY)	Project (CY)
Entrance Channel	3,496,900	3,386,500	35	38	121,980	139,200
Potrero Channel						
Pt. Richmond TB	931,000	0	35	38	45,050	0
Channel Section	5,172,000	5,008,700	35	38	164,480	187,760
Turning Basin	0	638,800	35	38	0	13,590
Potrero Sharp Turn	1,691,000	1,339,300	35	38	30,600	28,600
Inner Harbor Channel	3,729,000	3,396,600	35	38	56,520	60,690
Santa Fe Channel	400,000	400,000	35	38	6,080	6,080
Total	15,419,900	14,169,900			424,710	435,920

The maintenance clamshell dredging cost was estimated based on the following assumptions: (1) The Alcatraz disposal site will be used with a limitation of 100,000 CY of dredged material disposal per month; and (2) Dredging will be done with clamshell equipment working only one shift per day, five days per week, because of the disposal rate limitation. Inherent to the project's increased annual maintenance costs is the assumption that dredges will be available and Alcatraz will continue to be a viable disposal site.

At an average cost of $3.79/CY, the additional 11,210 CY of maintenance dredging will cost about $42,500 per year. The average annual cost for dredging the Richmond Inner Harbor, including the Santa Fe Channel from 1990 through 1994 is approximately $800,000. Therefore, the total annual O&M dredging cost after construction of the 38-foot project is

estimated to be $842,500.

6.3.2. - Non-Federal

The berthing areas located adjacent to the Richmond Harbor channels are currently maintained by the Port of Richmond to depths compatible with the -35 feet MLLW depth of the existing Federal Channel. Berthing area depths deepened for compatibility with the -38 foot MLLW project depth will not involve significant increases in non-Federal maintenance dredging.

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7.0 Implementation Requirements

7.1. - Coordination with Local Interests

The Department of the Army will enter into a Project Cooperation Agreement with the City of Richmond for the construction and maintenance of the Richmond Harbor Deep Water Ship Channel.

7.2. - Items of Local Cooperation

- Provide and maintain, at its own expense, any local service facilities that the non-Federal sponsor must provide because they are necessary to realize benefits from the general navigation features of the project.

- Provide all lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the general navigation features.

- Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the general navigation features and the local service facilities. Such improvements may include, but are not necessarily limited to, retaining dikes, waste weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

- Accomplish all removals determined necessary by the Federal Government other than those removals specifically assigned to the Federal Government.

- Provide, during the period of construction, a cash contribution equal to the following percentages of the total cost of construction of the general navigation features: 25 percent of the costs attributable to dredging to a depth in excess of 20 feet but not in excess of 45 feet;

- Repay with interest, over a period not to exceed 30 years following completion of the period of construction of the project, an additional 0 to 10 percent of the total cost of construction of general navigation features depending upon the amount of credit given for the value of lands, easements, rights-of-way, relocations, and borrow and dredged or excavated material disposal areas provided by the non-Federal sponsor for the general navigation features. If the amount of credit exceeds 10 percent of the total cost of construction of the general navigation features, the non-Federal sponsor shall not be required to make any contribution under this paragraph, nor shall it be entitled to any refund for the value of lands, easements, right-of-way, relocations, and dredged or excavated material disposal areas, in excess of 10 percent of the total cost of construction of the general navigation features.

- For so long as the project remains authorized, operate and maintain the local service

facilities and any dredged or excavated material disposal areas, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government.

· Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the general navigation features for the purpose of inspection, and, if necessary, for the purpose of operating and maintaining the general navigation features.

· Hold and save the United States free from all damages arising from the construction, operation, and maintenance of the project, any betterments, and the local service facilities, except for damages due to the fault or negligence of the United States or its contractors.

· Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as will properly reflect total cost of construction of the general navigation features, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 C.F.R. Section 33.20.

· Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, and maintenance of the general navigation features. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Federal Government provides the non-Federal Sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction.

· Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the general navigation features.

· To the maximum extent practicable, perform its obligations in a manner that will not cause liability to arise under CERCLA.

· Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for construction, operation, and maintenance, of the general

navigation features, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

· Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

· Provide a cash contribution equal to 25% of the total historic preservation mitigation and data recovery costs attributable to commercial navigation that are in excess of one percent of the total amount authorized to be appropriated for commercial navigation.

7.3. - Real Estate

The recommended plan of improvement for Richmond Harbor requires a temporary work area easement for one year that will include three areas. These areas are as follows: (a) 8.28 acres that will be used for the dewatering and aeration of dredged material, (b) a 300,000 square-foot "floating" construction area (out of 50.09 acres)—that will be used for the spreading of dredged material—after dewatering and aeration, and (c) 1.87 acres that includes Basin 1 of the graving docks and the adjoining roadway immediately west of Basin 1. For more details, see the Real Estate Plan in Appendix C.

7.4. - Project Schedule

The project schedule is shown in Figure 17.

7.5. - Activities that must precede construction

There are several activities that must be completed prior to award of the construction contracts for the deepening project. A rough description of these activities (excluding review and approval of the GDM, NEPA documentation, and plans and specifications) and the associated relationships with the project schedule are given below:

a. Project Cooperation Agreement. A PCA between the Corps and the City of Richmond must be executed prior to the advertisement of the construction contract. The Port is scheduled to initiate acquisition and site preparation activities immediately following enactment of the agreement. The current schedule for PCA signature is 1 July 1996.

b. EPA Concurrence for use of Section 102 Site. The Environmental Protection Agency has designated the Ocean Section 102 disposal site as a "multi-use" site. After notice by the Corps, the EPA will determine whether concurrence on the use of this site for the navigation improvement project's "suitable" material is appropriate.

c. Parking Lot Drying Area Preparation. Site preparation of the drying area for unsuitable material which will be placed in the parking lot next to the Point Potrero Marine

Terminal must be completed prior to disposal (see Figure 15). The site preparation includes lining the area to prevent groundwater contamination and, if necessary, dike construction to prevent runoff into the harbor. The Port of Richmond is responsible for these features.

7.6. - Construction Funding Schedule

Based on the current project schedule shown in Figure 17, the annual funding requirements for construction of the recommended plan are shown in Table 9.

7.7. - Section 902 Funding Limitation

The Water Resources Development Act (WRDA) of 1986, Public Law 99-662 Section 202, authorized deepening of the Richmond Harbor at an estimated cost of $43,800,000.

Section 902 of WRDA 86 restricts increases over the authorized cost to 20 percent (except for price level increases and subsequent authorizations). The section 902 cost limitation only applies to the cost of the recommended plan that is allocated to a navigation purpose.

The current estimated cost for the Richmond Harbor project is $33,693,000 (rounded); therefore, Section 902 does not apply.

RICHMOND 38-FOOT PROJECT SCHEDULE

NAME	1996	1997	1998	1999
	Qtr1 Qtr2 Qtr3 Qtr4	Qtr1 Qtr2 Qtr3 Qtr4	Qtr1 Qtr2 Qtr3 Qtr4	Qtr1 Qtr2 Qtr3 Qtr4
SUBMIT FINALGDM TO HQUSACE	4/1/96			
SIGN RECORD OF DECISION (ROD)	6/5/96			
SIGN PCA	7/1/96			
APPROVE PLANS & SPECIFICATIONS	7/15/96			
ADVERTISE CONSTRUCTION CONTRACT	7/15/96 - 8/15/96			
OPEN BIDS, SELECT CONTRACTOR	8/16/96 - 8/28/96			
AWARD CONSTRUCTION CONTRACT	8/28/96			
CONSTRUCT RICHMOND 38ft PROJECT	8/28/96		6/28/97-11/28/97	

CONTRA COSTA COUNTY CALIFORNIA

RICHMOND HARBOR 38-FOOT PROJECT
PHASE I

PROJECT SCHEDULE

IN SHEET SHEET NO.
U S ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN FILE NO
TRACED TO ACCOMPANY REPORT
CHECKED DATED

FIGURE /17

Table 9

Richmond 38-Foot Project
Annual Funding Requirements
($000)

Account	*Description*	*FY 96*	*FY 97*	*FY 98*	**Total**
00	Aids to Navigation		$130		$130
12	Navigation Ports	700	18,000	3,200	21,900
12	Berth Dredging		650		650
30	Plan., Engr. & Des.	9,200	400	50	9,650
31	Super. & Admin.	50	1,200	100	1,350
	Total	$9,950	$20,380	$3,350	$33,680

8.0 Conclusions and Recommendations

8.1. - Conclusions

The District Engineer concludes that improvement of the Richmond Harbor navigation channel, as described herein, conforms with the expressed concerns and needs of local interests and the Federal government, and is justified on the basis of tangible benefits in the form of monetary transportation savings in excess of project costs.

8.2. - Recommendations

In developing this recommendation, I have considered all significant aspects of the overall public interest, including environmental, social, and economic effects as well as engineering feasibility. As a result, I recommend that the 38-foot Richmond Harbor Navigation Improvement project should be implemented as described in this design memorandum. The project construction cost to the United States is currently estimated at $22,236,000. The non-Federal cost is currently estimated at $11,457,000.

In conclusion, I recommend the approval of this General Design Memorandum as the basis for the preparation of contract plans and specifications.

Michael J. Walsh

MICHAEL J. WALSH
LTC, EN
Commanding

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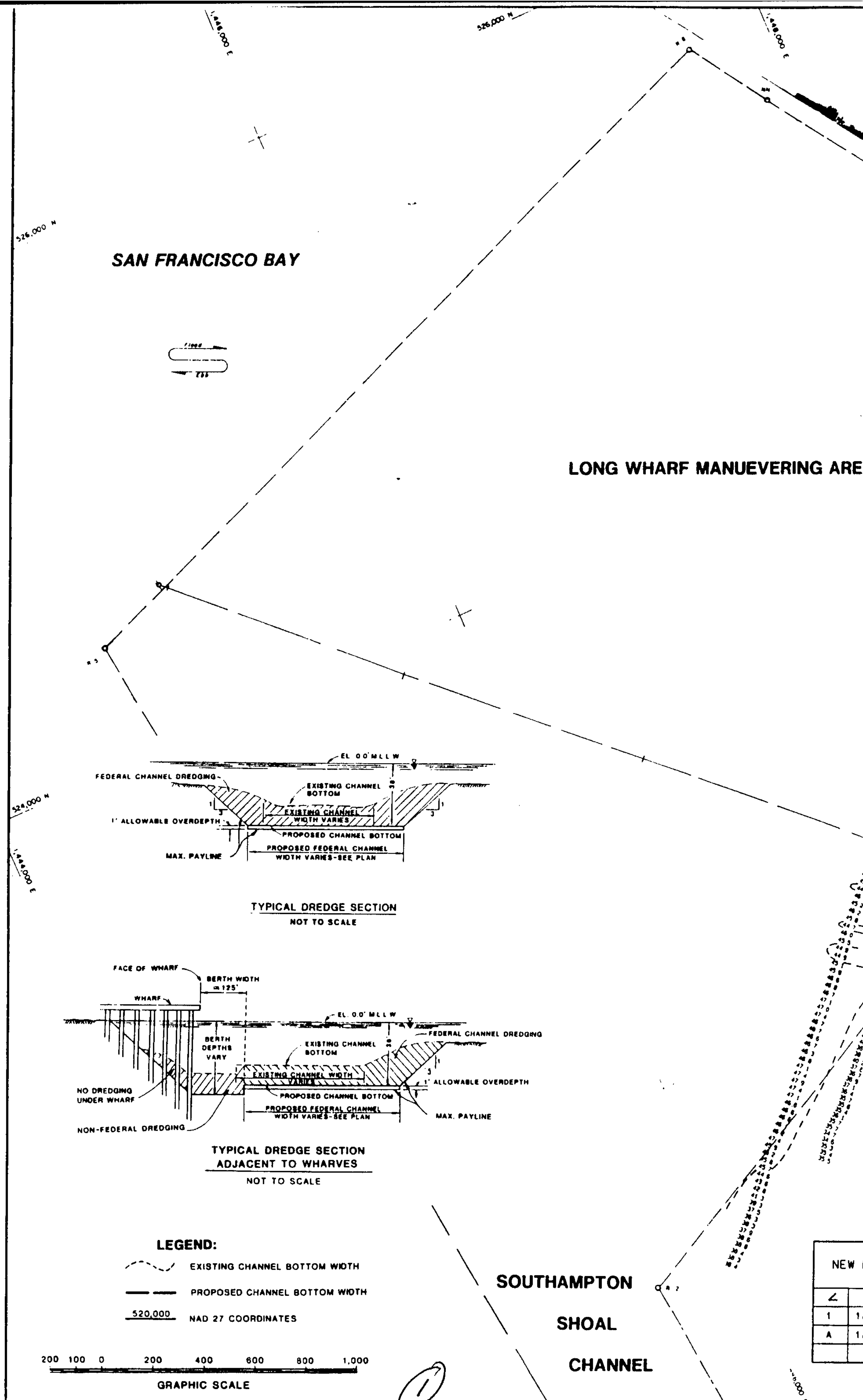
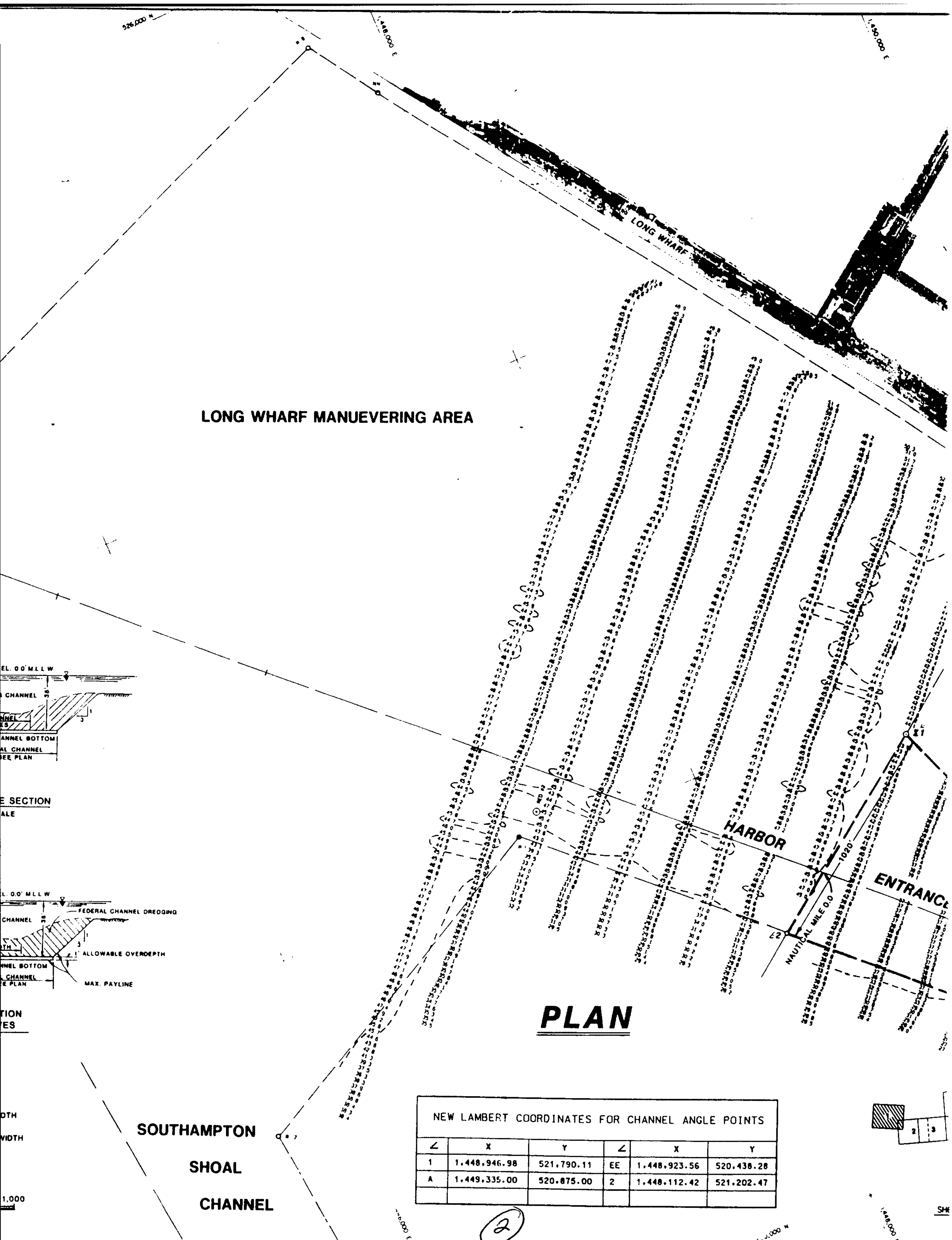
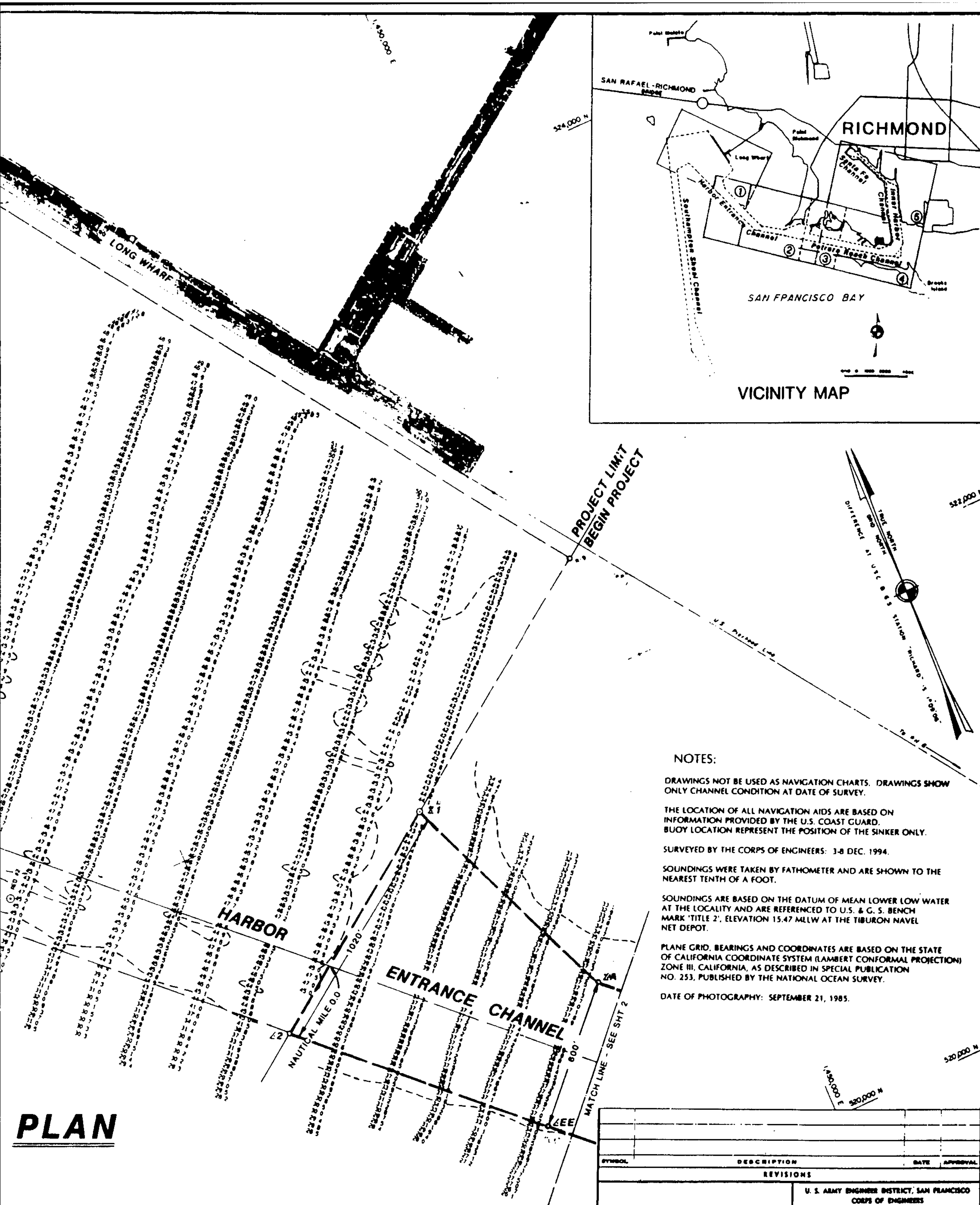


SAN FRANCISCO BAY
LONG WHARF MANUEVERING ARE.
526,000 N
524,000 N
1,444,000 E
1,446,000 E
1,448,000 E
EL. 0.0' MLLW
FEDERAL CHANNEL DREDGING
EXISTING CHANNEL BOTTOM
EXISTING CHANNEL WIDTH VARIES
1' ALLOWABLE OVERDEPTH
PROPOSED CHANNEL BOTTOM
PROPOSED FEDERAL CHANNEL WIDTH VARIES-SEE PLAN
MAX. PAYLINE
TYPICAL DREDGE SECTION
NOT TO SCALE
FACE OF WHARF
BERTH WIDTH ≈125'
WHARF
BERTH DEPTHS VARY
NO DREDGING UNDER WHARF
NON-FEDERAL DREDGING
TYPICAL DREDGE SECTION ADJACENT TO WHARVES
NOT TO SCALE
LEGEND:
EXISTING CHANNEL BOTTOM WIDTH
PROPOSED CHANNEL BOTTOM WIDTH
520,000 NAD 27 COORDINATES
200 100 0 200 400 600 800 1,000
GRAPHIC SCALE
SOUTHAMPTON
SHOAL
CHANNEL
NEW L
1
A



NEW LAMBERT COORDINATES FOR CHANNEL ANGLE POINTS					
∠	X	Y	∠	X	Y
1	1.448.946.98	521.790.11	EE	1.448.923.56	520.438.28
A	1.449.335.00	520.875.00	2	1.448.112.42	521.202.47



NOTES:

DRAWINGS NOT BE USED AS NAVIGATION CHARTS. DRAWINGS SHOW ONLY CHANNEL CONDITION AT DATE OF SURVEY.

THE LOCATION OF ALL NAVIGATION AIDS ARE BASED ON INFORMATION PROVIDED BY THE U.S. COAST GUARD. BUOY LOCATION REPRESENT THE POSITION OF THE SINKER ONLY.

SURVEYED BY THE CORPS OF ENGINEERS: 3-8 DEC. 1994.

SOUNDINGS WERE TAKEN BY FATHOMETER AND ARE SHOWN TO THE NEAREST TENTH OF A FOOT.

SOUNDINGS ARE BASED ON THE DATUM OF MEAN LOWER LOW WATER AT THE LOCALITY AND ARE REFERENCED TO U.S. & G. S. BENCH MARK 'TITLE 2', ELEVATION 15.47 MLLW AT THE TIBURON NAVEL NET DEPOT.

PLANE GRID, BEARINGS AND COORDINATES ARE BASED ON THE STATE OF CALIFORNIA COORDINATE SYSTEM (LAMBERT CONFORMAL PROJECTION) ZONE III, CALIFORNIA, AS DESCRIBED IN SPECIAL PUBLICATION NO. 253, PUBLISHED BY THE NATIONAL OCEAN SURVEY.

DATE OF PHOTOGRAPHY: SEPTEMBER 21, 1985.

ORDINATES FOR CHANNEL ANGLE POINTS

Y	∠	X	Y
521.790.11	EE	1.448.923.56	520.438.28
520.875.00	2	1.448.112.42	521.202.47

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DRAWN BY:
TRACED BY:
CHECKED BY:
SUBMITTED:
APPROVAL RECOMMENDED:
APPROVED:
DATE:

CONTRA COSTA COUNTY CALIFORNIA

RICHMOND HARBOR (PHASE I)

RECOMMENDED PLAN

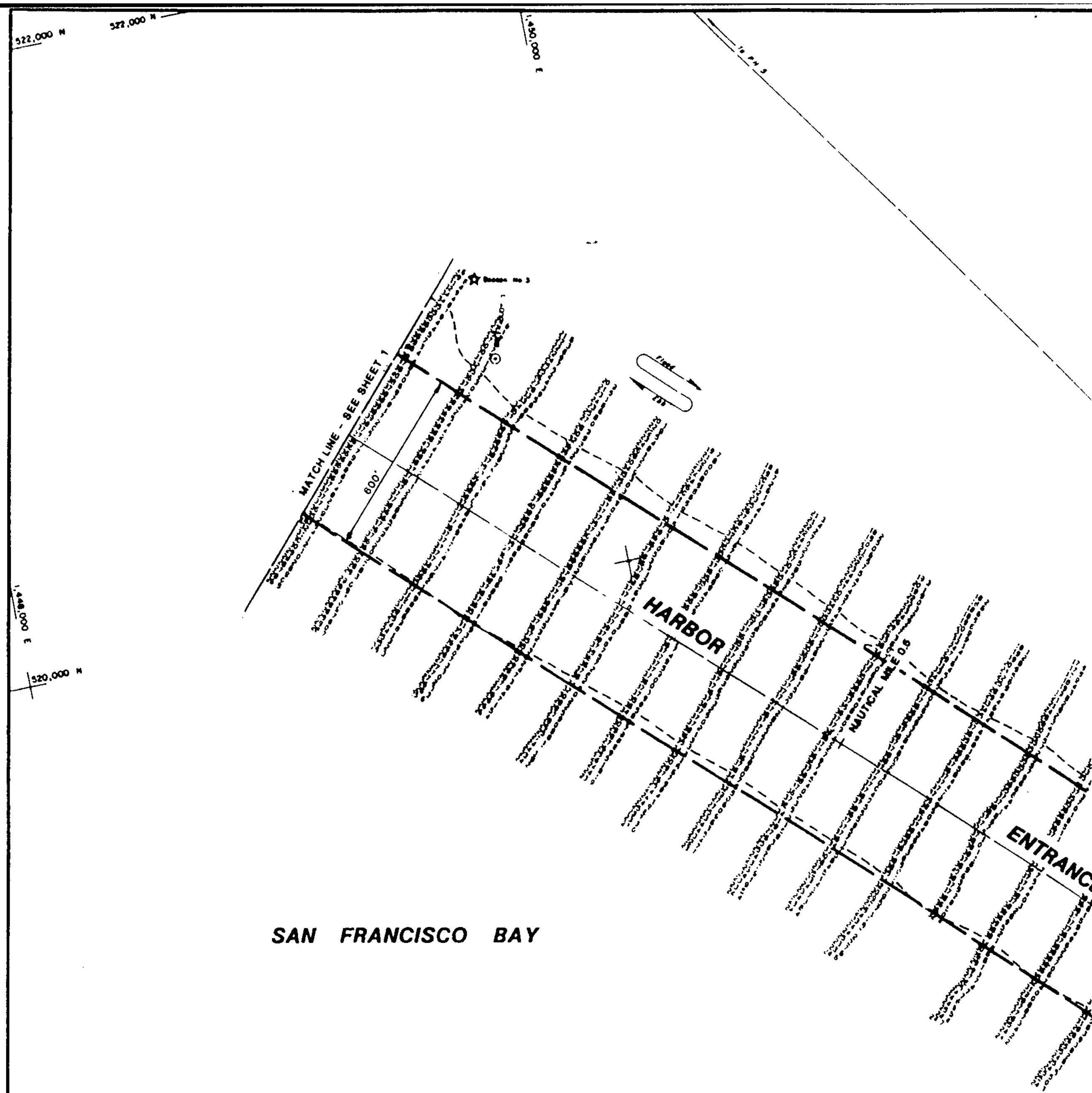
DEEPENING TO -38 FEET MLLW

PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E., DISTRICT ENGINEER

SCALE: 1" = 200'
JOB No.
DRAWING NUMBER
SHEET 1 of 5

3

PLATE 1



NEW LAMBERT COORDINATES FOR CHANNEL ANGLE POINTS					
∠	X	Y	∠	X	Y
B	1,451,703.60	518,643.50	E	1,454,000.53	517,934.83
C	1,452,579.14	518,183.29	DD	1,451,913.26	517,621.64

PLAN

518,000 N

LEGEND:

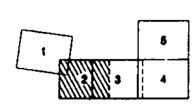
EXISTING CHANNEL BOTTOM WIDTH

PROPOSED CHANNEL BOTTOM WIDTH

520,000 NAD 27 COORDINATES

200 100 0 200 400 600 800 1,000

GRAPHIC SCALE

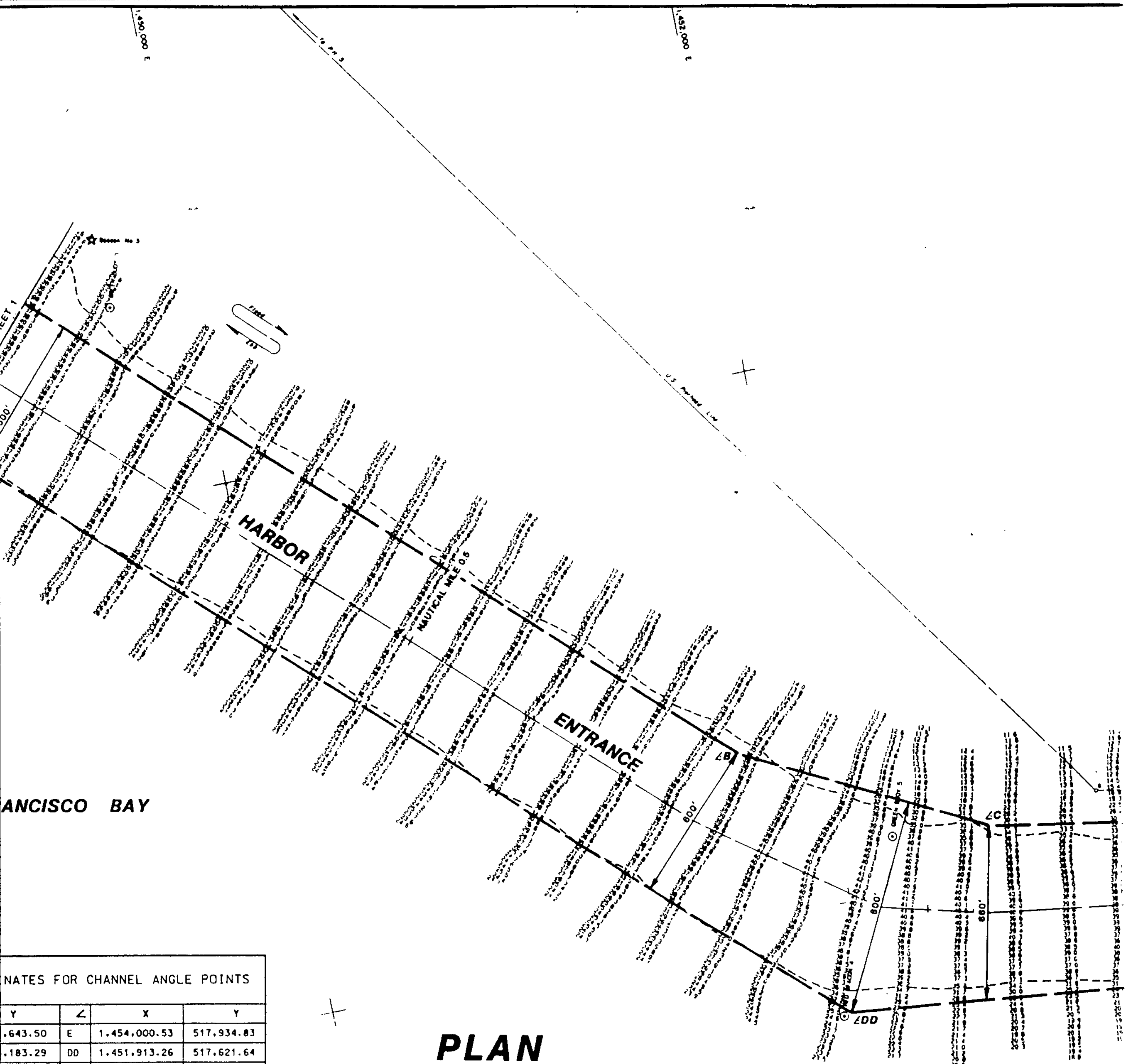


SHEET INDEX

1,448,000 E

1

1,450,000 E



NATES FOR CHANNEL ANGLE POINTS			
Y	∠	X	Y
,643.50	E	1,454,000.53	517,934.83
.183.29	DD	1,451,913.26	517,621.64

PLAN

LEGEND:

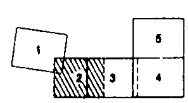
EXISTING CHANNEL BOTTOM WIDTH

PROPOSED CHANNEL BOTTOM WIDTH

000 NAD 27 COORDINATES

00 400 600 800 1,000

GRAPHIC SCALE



SHEET INDEX

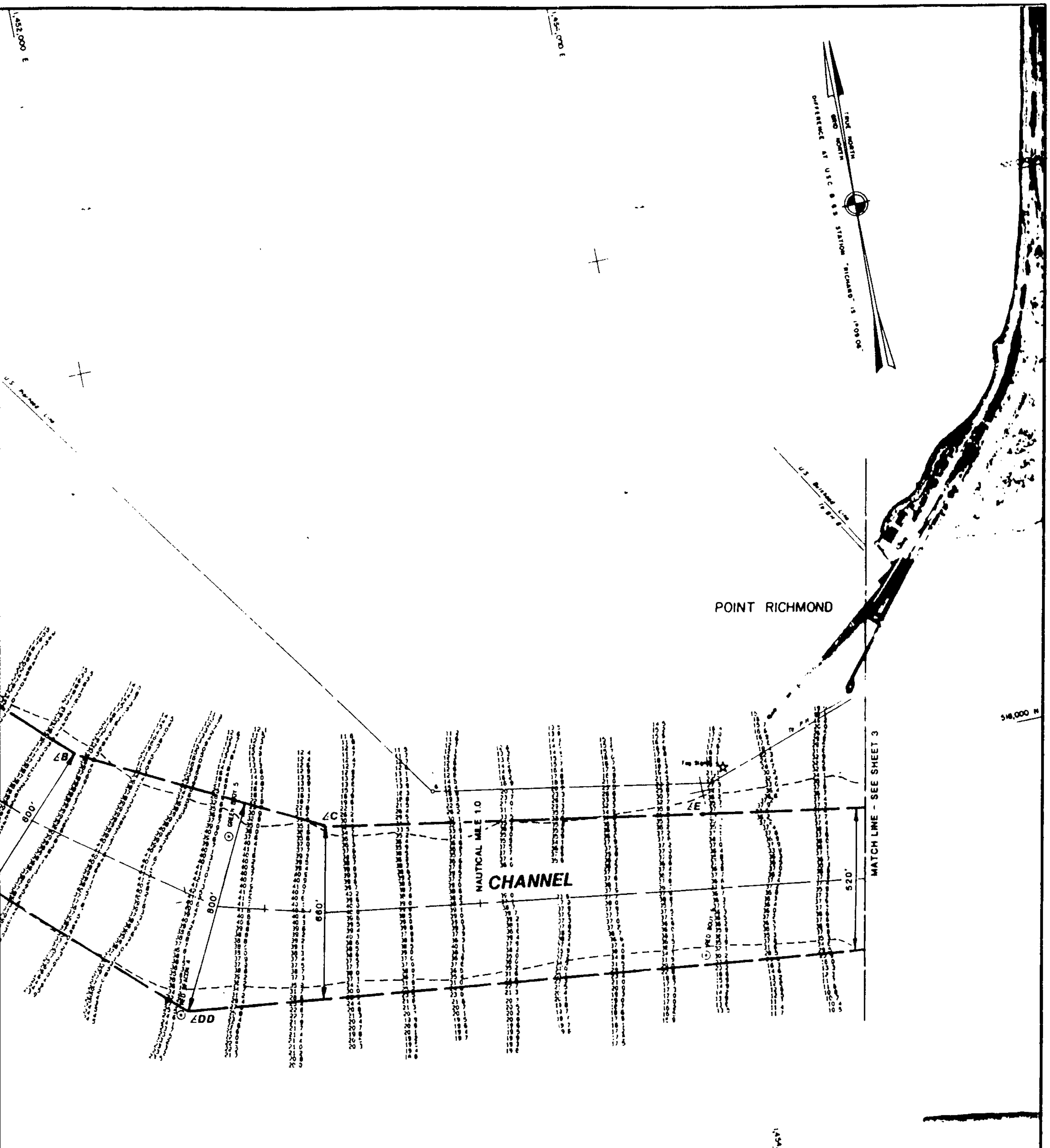
NOTES:

1. FOR NOTES SEE SHEET 1.
2. PER COAST GUARD APPROVAL, MOVE GREEN BUOY 5 AND RED BUOY 6 OUTSIDE OF CHANNEL

1,450,000 E

1,452,000 E

516,000 N



NOTES:

1. FOR NOTES SEE SHEET 1.
2. PER COAST GUARD APPROVAL, MOVE GREEN BUOY 5 AND RED BUOY 6 OUTSIDE OF CHANNEL

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DRAWN BY:
TRACED BY:
CHECKED BY:
SUBMITTED:

CONTRA COSTA COUNTY — CALIFORNIA

RICHMOND HARBOR (PHASE I)

RECOMMENDED PLAN

DEEPENING TO -38 FEET MLLW

APPROVAL RECOMMENDED: — APPROVED: — DATE:

PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E., DISTRICT ENGINEER

SCALE: 1" = 200' — JOB NO. — DRAWING NUMBER

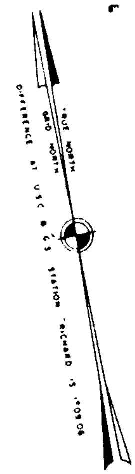
SHEET 2 of 5

3

PLATE 2

1,452,000 E

1,454,000 E



P
R

520,000 N

SAN FRANCISCO BAY

518,000 N

NEW LAMBERT COORDINATES FOR CHANNEL ANGLE POINTS					
∠	X	Y	∠	X	Y
H	1.456.138.77	517.561.05	CC	1.455.058.67	517.242.28

NOTES:

FOR NOTES SEE SHEET 1

LEGEND:

EXISTING CHANNEL BOTTOM WIDTH

PROPOSED CHANNEL BOTTOM WIDTH

520,000 NAD 27 COORDINATES

NOTES:

FOR NOTES SEE SHEET 1.

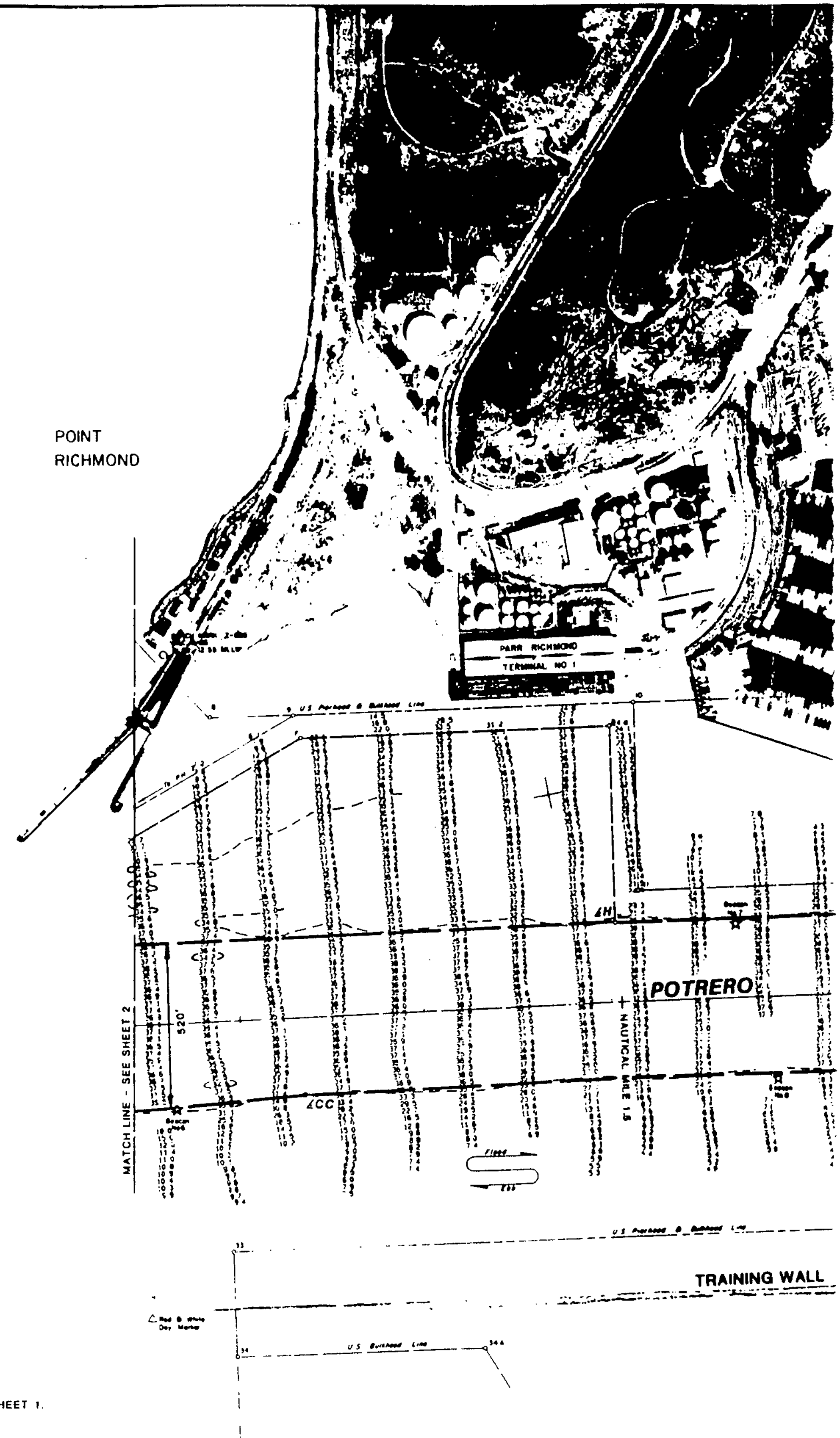
200 100 0 200 400 600 800 1,000

GRAPHIC SCALE

1,452,000 E

516,000 N

1



FRANCISCO BAY

CHANNEL ANGLE POINTS		
∠	X	Y
	1,455,058.67	517,242.28

CHANNEL BOTTOM WIDTH

CHANNEL BOTTOM WIDTH

ORDINATES

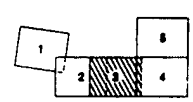
600 800 1,000

E

NOTES:

FOR NOTES SEE SHEET 1.

PLAN



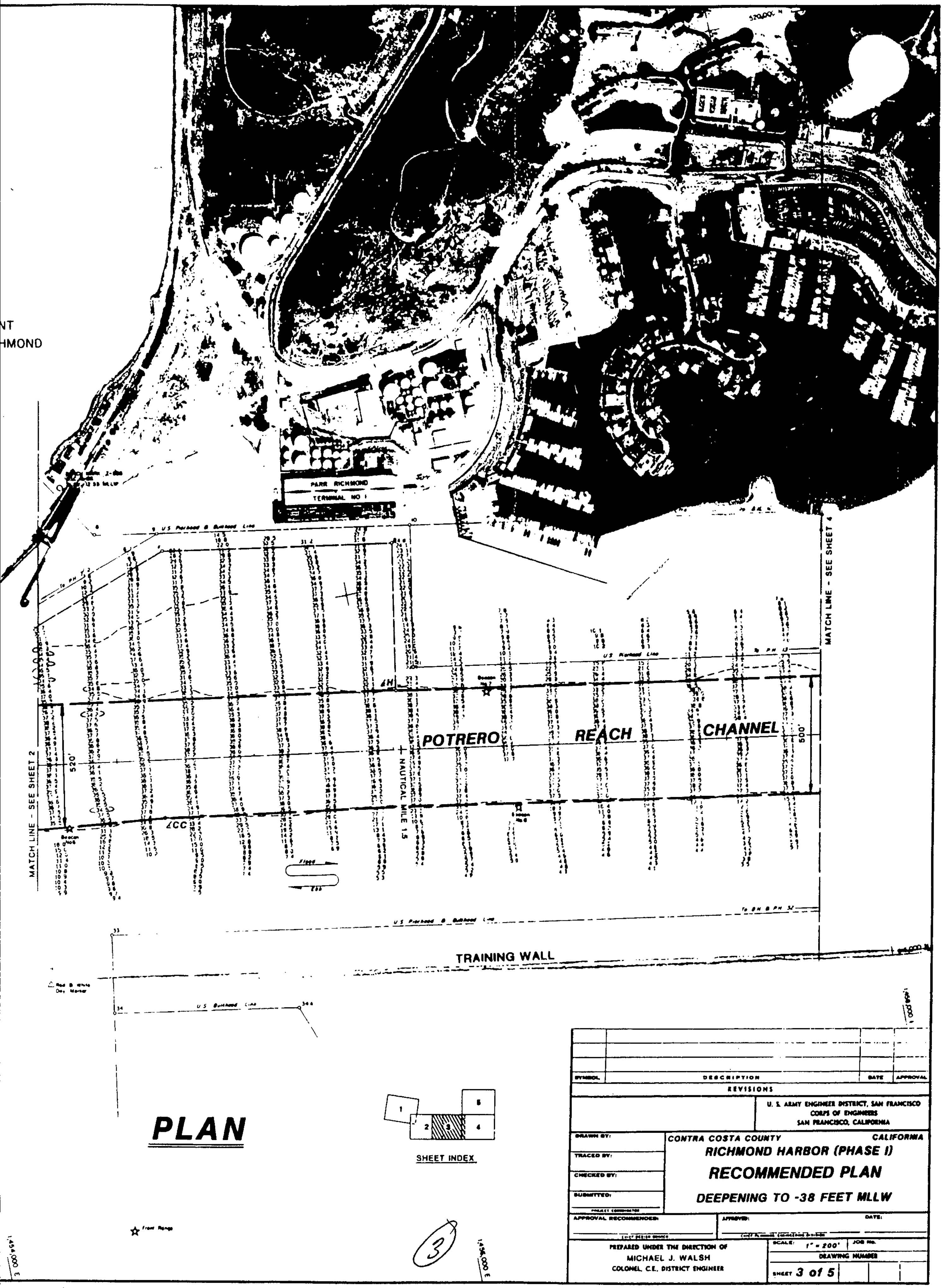
SHEET INDEX

Front Range

1,454,000 E

1,456,000 E

2


PARR RICHMOND
TERMINAL NO 1
U S Pierhead & Bulkhead Line
MATCH LINE - SEE SHEET 2
MATCH LINE - SEE SHEET 4
POTRERO
REACH
CHANNEL
NAUTICAL MILE 1.5
520'
500'
Flood
Ebb
U S Pierhead & Bulkhead Line
TRAINING WALL
U S Bulkhead Line
PLAN
SHEET INDEX
SYMBOL
DESCRIPTION
DATE
APPROVAL
REVISIONS
U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA
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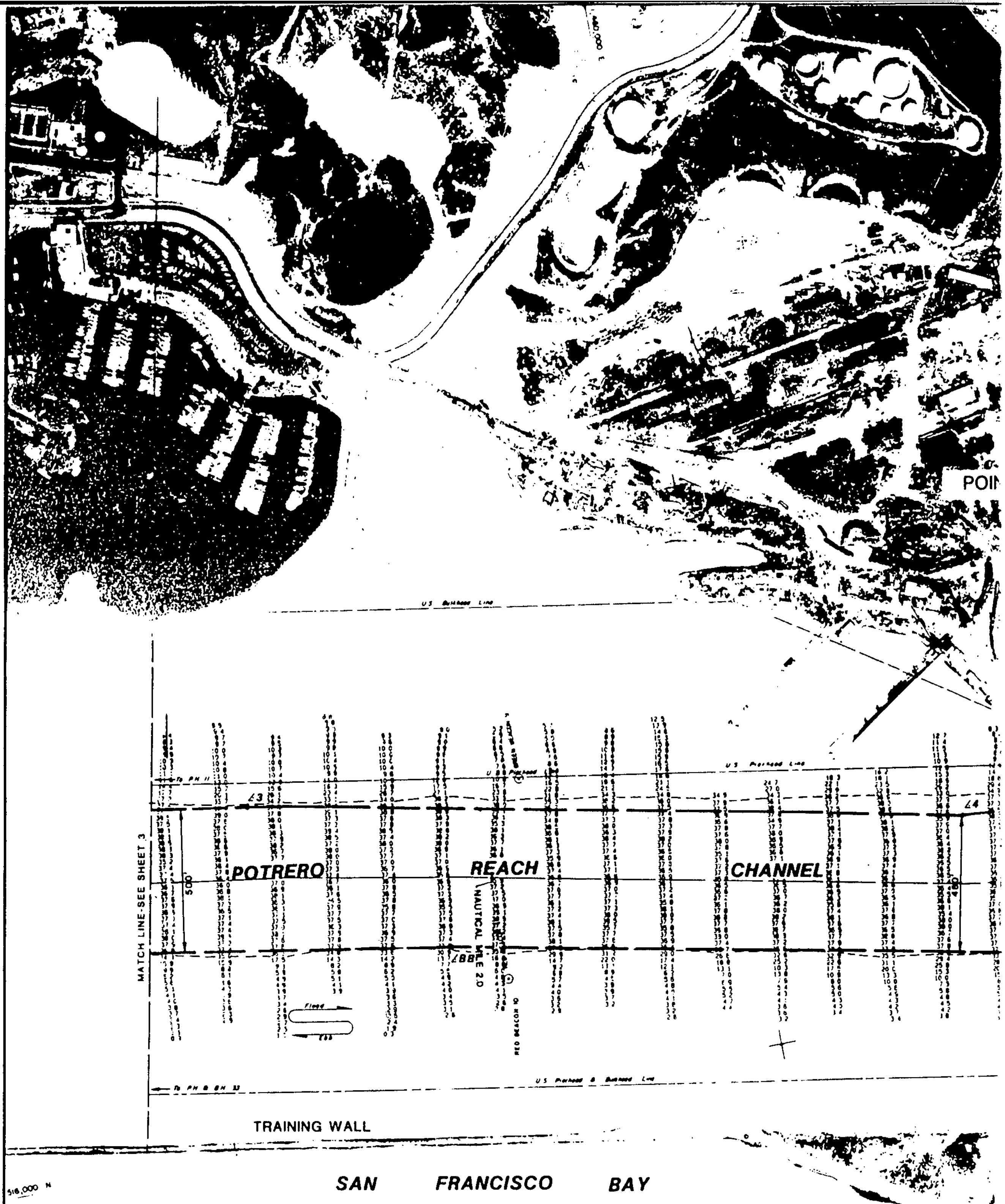
SCALE: 1" = 200'
JOB No.
DRAWING NUMBER
SHEET 3 of 5
3



LEGEND:

EXISTING CHANNEL BOTTOM WIDTH

PROPOSED CHANNEL BOTTOM WIDTH

520,000 NAD 27 COORDINATES

200 100 0 200 400 600 800 1,000

GRAPHIC SCALE

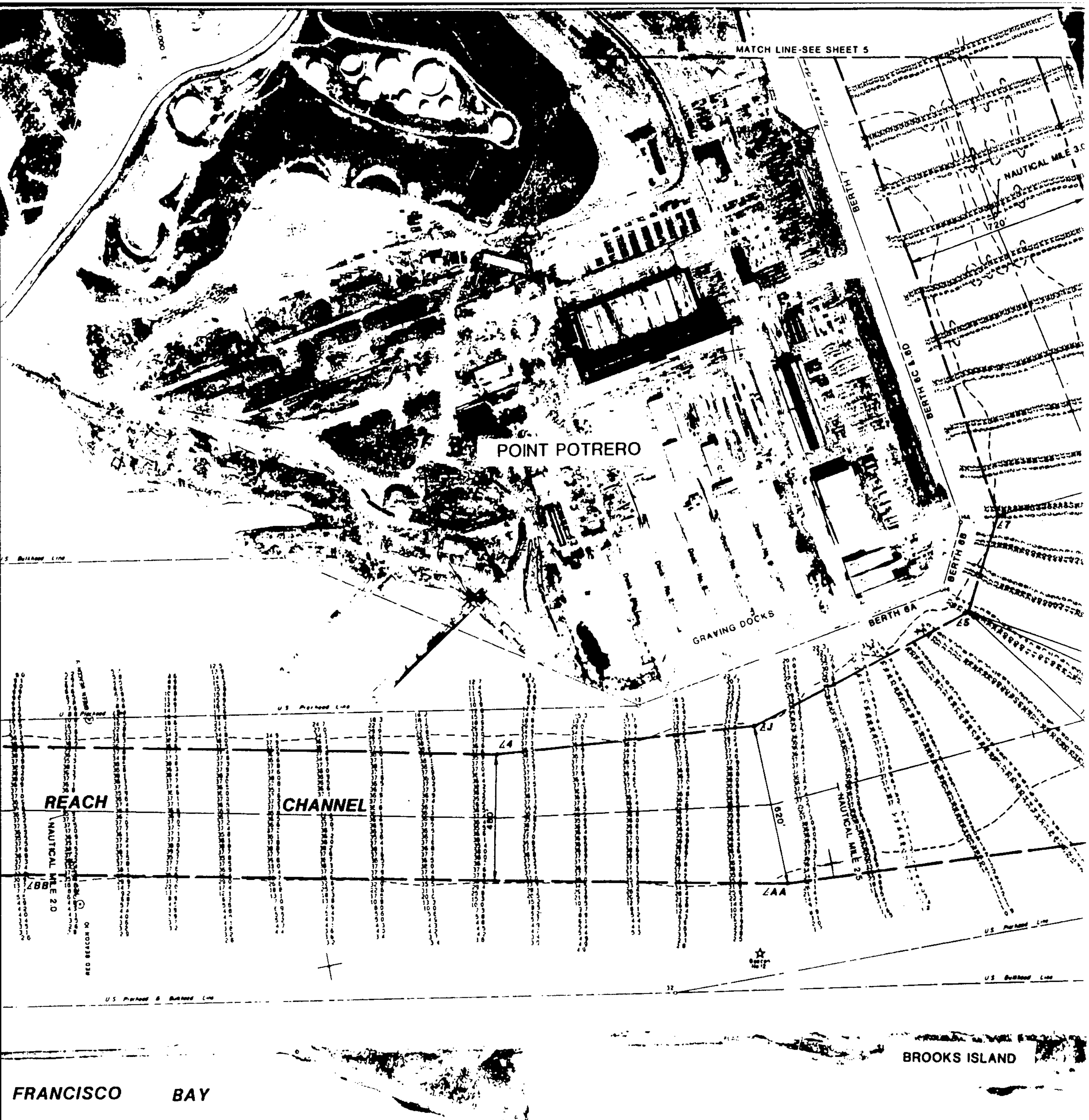
NEW LAMBERT COORDINATES FOR CHANNEL ANGLE POINTS

∠	X	Y	∠	X	Y
3	1.458.444.56	517.157.98	9	1.463.898.05	516.610.19
4	1.460.811.95	516.660.95	8	1.463.725.19	516.128.13
J	1.461.807.81	516.570.06	6	1.463.430.14	515.848.85
5	1.462.704.29	516.836.24	Z	1.462.773.34	515.893.70
7	1.462.877.20	517.164.54	AA	1.461.820.31	515.958.78
10	1.463.426.90	518.291.81	BB	1.458.931.60	516.565.26

1,458,000 E

1

1,460,000 E



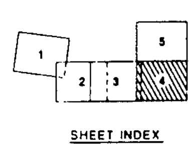
PLAN

NEW LAMBERT COORDINATES FOR CHANNEL ANGLE POINTS

∠	X	Y	∠	X	Y
3	1.458.444.56	517.157.98	9	1.463.898.05	516.610.19
4	1.460.811.95	516.660.95	8	1.463.725.19	516.128.13
J	1.461.807.81	516.570.06	6	1.463.430.14	515.848.85
5	1.462.704.29	516.836.24	Z	1.462.773.34	515.893.70
7	1.462.877.20	517.164.54	AA	1.461.820.31	515.958.78
10	1.463.426.90	518.291.81	BB	1.458.931.60	516.565.26

NOTES:

FOR NOTES SEE SH



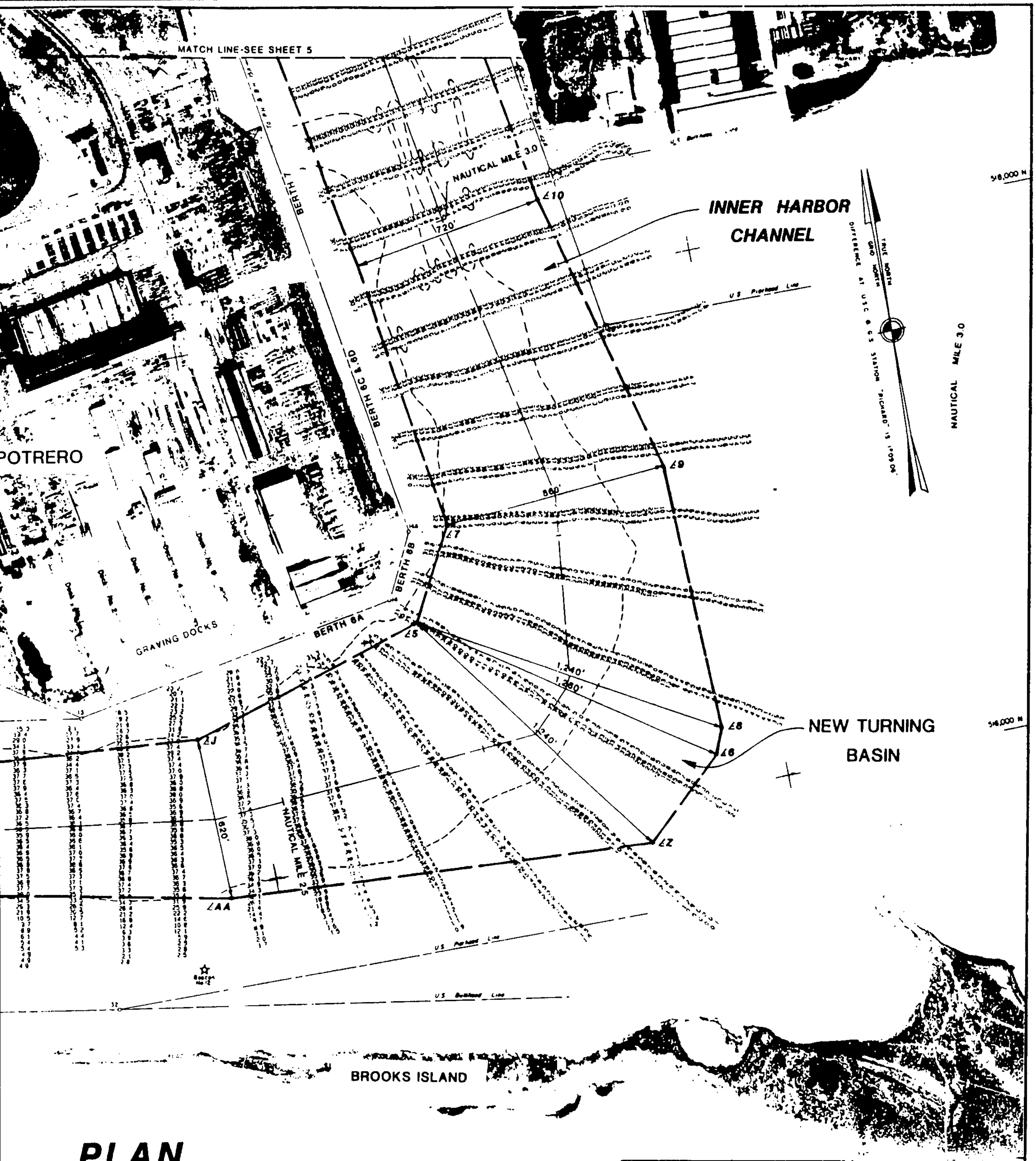
SHEET INDEX

1,460,000 E

1,462,000 E

514,000 N

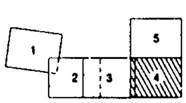
2



PLAN

NOTES:

FOR NOTES SEE SHEET 1.



SHEET INDEX

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DRAWN BY:
TRACED BY:
CHECKED BY:
SUBMITTED:

CONTRA COSTA COUNTY — CALIFORNIA

RICHMOND HARBOR (PHASE I)

RECOMMENDED PLAN

DEEPENING TO -38 FEET MLLW

APPROVAL RECOMMENDED: — APPROVED: — DATE:

PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E., DISTRICT ENGINEER

SCALE: 1" = 200'

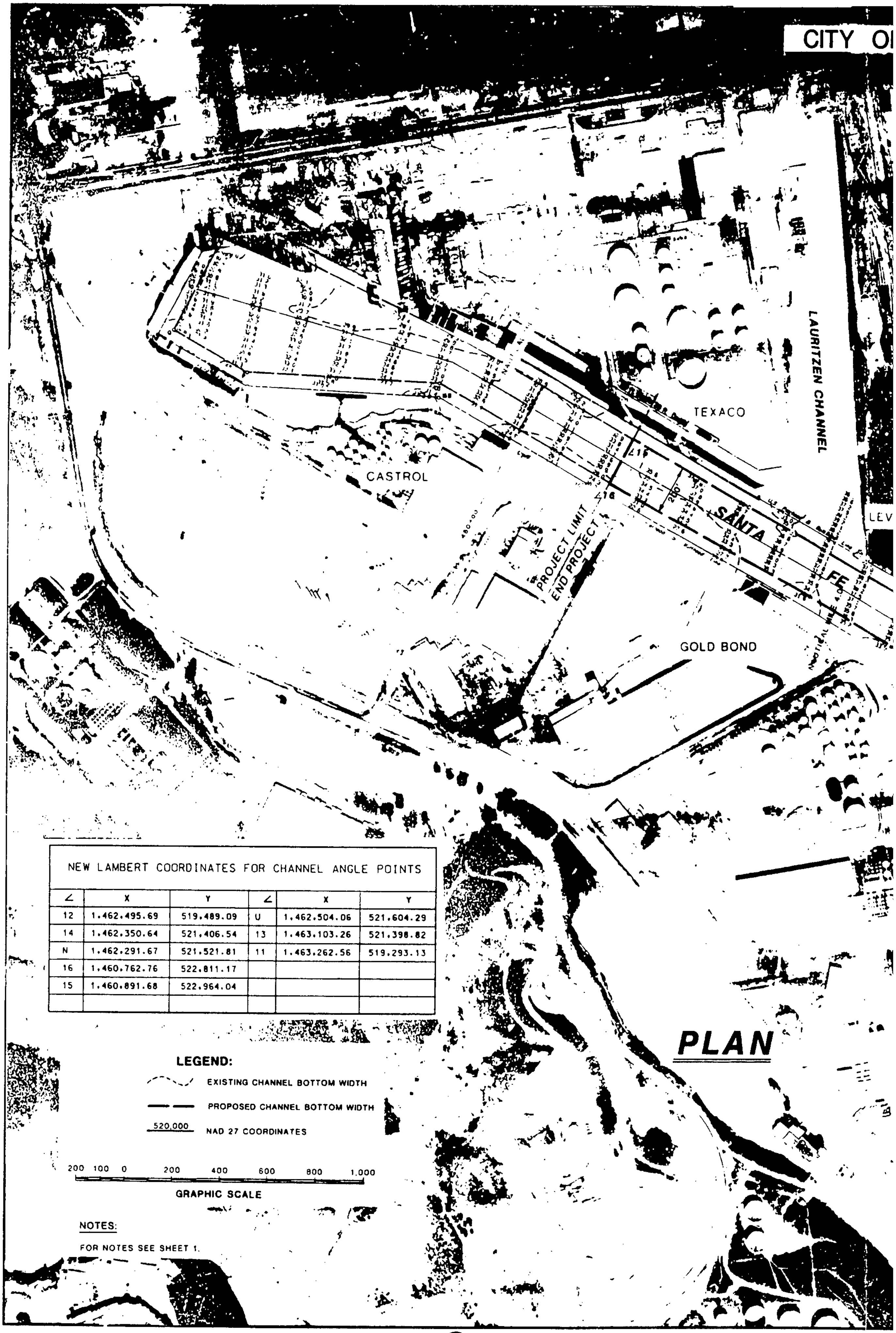
DRAWING NUMBER

SHEET 4 of 5

514,000 N

462,000 E

(3)



NEW LAMBERT COORDINATES FOR CHANNEL ANGLE POINTS

∠	X	Y	∠	X	Y
12	1.462.495.69	519.489.09	U	1.462.504.06	521.604.29
14	1.462.350.64	521.406.54	13	1.463.103.26	521.398.82
N	1.462.291.67	521.521.81	11	1.463.262.56	519.293.13
16	1.460.762.76	522.811.17			
15	1.460.891.68	522.964.04			

LEGEND:

EXISTING CHANNEL BOTTOM WIDTH

PROPOSED CHANNEL BOTTOM WIDTH

520,000 NAD 27 COORDINATES

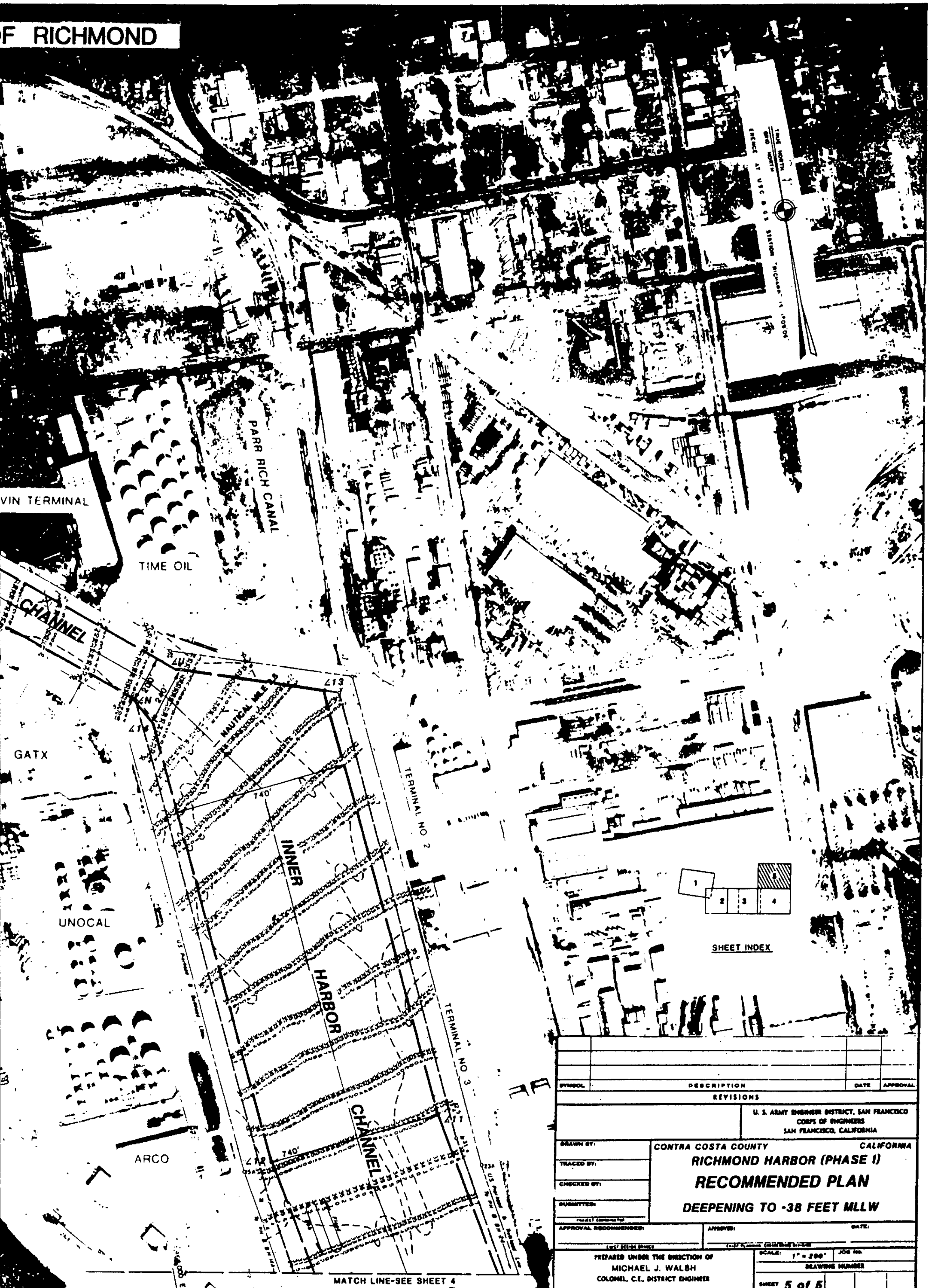
200 100 0 200 400 600 800 1,000

GRAPHIC SCALE

NOTES:

FOR NOTES SEE SHEET 1.


CITY OF RICHMOND
TEXACO
LAURITZEN CHANNEL
CASTROL
LEVIN TERMINAL
PARR RICH CANAL
TIME OIL
SANTA FE CHANNEL
PROJECT LIMIT
END PROJECT
GOLD BOND
GATX
NAUTICAL MILE
740'
INNER HARBOR CHANNEL
TERMINAL NO 2
TERMINAL NO 3
UNOCAL
ARCO
PLAN
GLE POINTS
Y
521.604.29
521.398.82
519.293.13
1,000
MATCH LINE-SEE SHEET 4



SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DRAWN BY:
TRACED BY:
CHECKED BY:
SUBMITTED:

CONTRA COSTA COUNTY — CALIFORNIA

RICHMOND HARBOR (PHASE I)

RECOMMENDED PLAN

DEEPENING TO -38 FEET MLLW

APPROVAL RECOMMENDED:
APPROVED:
DATE:

PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E., DISTRICT ENGINEER

SCALE: 1" = 200'
JOB NO.
DRAWING NUMBER
SHEET 5 of 5

(3)

PLATE

GDM Appendices

for

Navigation Channel Deepening

Richmond Harbor
38-Foot Project

FINAL REPORT

Prepared by:

U.S. Army Corps of Engineers
San Francisco District
January 1996

Appendix A

Geotechnical Engineering Report

APPENDIX ~~K~~A

Geotechnical Engineering, Richmond Harbor Deepening

GENERAL

The Geotechnical Engineering Section of the overall Engineering Appendix for the Richmond Harbor Deepening Project is written to address Phase I of the project as essentially presented in the "Richmond Harbor Deep-Draft Navigation Project - Plan of Action" dated October 1985 and approved by the South Pacific Division on 10 January 1986. The Phase I project depth is -38 feet mean lower low water (MLLW) datum. The allowable overdredge depth will be held to a one foot tolerance in those areas underlain by soft material and one foot overdredge plus one foot of tolerance in those portions of the project underlain by hard materials including rock and stiff clays. The Phase II deepening is not specifically addressed in this section.

GEOLOGY

The Richmond Harbor is located near the north end and on the east side of San Francisco Bay. The project includes the entrance channel, the Potrero Reach Channel and sharp turn area, Inner Harbor Channel, and Santa Fe Channel. The Richmond Inner Harbor and Santa Fe Channel facilities were constructed by placing fill on salt-water marsh land along a tidal slough. The slough was deepened and expanded to the present channel configuration by dredging. The fill extends in to the San Francisco Bay. The Richmond Inner Harbor is situated on the southern edge of a relatively low lying plane that is bounded on the east by the San Pablo Creek - Wildcat Creek alluvial fan and by the San Pablo Hills on the west. The low lying plane is composed of marsh land deposits and artificial fill on marsh land. The alluvial fan rises approximately 120 feet in 3 miles from its contact with the marsh land deposits to the base of the East Bay - Berkeley Hills in the east. The San Pablo Hills on the west rise abruptly above the low lying plane to an elevation of nearly 500 feet at the highest point. The Potrero Reach Channel leading into the Inner Harbor through the Potrero sharp turn area crosses an inundated, naturally occurring, low bedrock saddel connecting Potrero Point with Brooks Island.

San Francisco Bay is a relatively young, trough shaped geological feature that was formed by tectonic warping and faulting that began in late Pliocene time, approximately 2 million years ago, and carried on into the Pleistocene time. Approximately one million years ago, Middle Pleistocene time, the San Francisco Bay began taking the shape as we know today by down faulting, mountain uplifting, and sea level fluctuations from world wide glaciation. Faulting and uplift of the surrounding coast range mountains are still occurring to the present as evidenced by active faults on each side of San Francisco Bay and by Pleistocene coastal terraces that are too high to be accounted for by interglacial high stands of the sea, and by warping of even some of the younger terraces.

The sediments found within the San Francisco Bay have been deposited during various periods of sea level fluctuations caused by the advance and retreat of glacial ice sheets. The oldest sediments, known as the Alameda Formation, are apparently a combination of marine and non-marine sediments deposited during the various periods of glacial advance and retreat prior to the last major interglacial period of high sea level stand. During that interglacial period of approximately 70,000 to 100,000 years ago, the Sangamon interglacial period, the marine clays of the San Antonio Formation were probably deposited along with non-marine sediments being deposited on the alluvial plains surrounding the bay. During the succeeding period of world wide glaciation called the Wisconsin glacial period there appears to have been several periods of glacial advances and retreats with corresponding sea level changes. It is probable that during a glacial fluctuation in the early part of the Wisconsin glacial period brown, clayey alluvial materials were deposited and coalesced with colluvial deposits of the San Pablo Hills. The sediments of the alluvial fans were being deposited and continued to be deposited up into the present time. At the end of the Wisconsin glacial period, the sea level began to rise, and 10,000 years ago the sea entered San Francisco Bay at the Golden Gate. The sea nearly reached its present level 5,000 to 6,000 years ago. It is during this later period since the end of the last glacial period that soft, young mud has been deposited in San Francisco Bay.

The San Pablo Hills trend northwest and forms a ridge generally less than one mile wide and approximately 5.2 miles in length. The San Pablo Hills is a fault block mountain ridge composed primarily of sandstone with some interbedded shale and belongs to the Jurassic - Cretaceous Franciscan Complex. The San Pablo Hills block is bounded on the east by the concealed and inferred San Pablo fault and by an inferred fault on the west. Brooks Island, rising to approximately 160 feet NGVD, appears to be a continuation of the San Pablo block. It is composed of Franciscan sandstone and lies across the Richmond Inner Harbor Channel from Potrero Point. However, Brooks Island has been separated from the San Pablo block by a naturally occurring bedrock erosional feature that apparently extends deeper than -60 feet mean lower low water (MLLW). The southern end of the San Pablo Hills at Potrero Point has been excavated into and lowered for the construction of port related facilities.

Within the Richmond Inner Harbor Deepening Project, sediments of very soft to soft Younger Bay Mud, firm to stiff brown clays with occasional minor sand lenses, and firm to very stiff dark bluish gray to greenish gray clays of Older Bay Mud (probable San Antonio equivalent) with minor sand lenses are expected to be dredged. The Younger Bay Mud ranges in thickness from a few feet along the shoreline to greater than 60 feet near Potrero Point and in the Harbor Entrance Channel. Franciscan bedrock has previously been excavated from two limited areas of the channel at Potrero Point during the mid-1950's to allow the channel to be deepened to its current design depth of -35 feet MLLW.

2. SEISMICITY. The Richmond Inner Harbor lies within the influence of the seismically active San Andreas fault zone and its related faults. The active faults expected to have the greatest impact upon the Richmond Inner Harbor project are San Andreas fault and the Hayward fault. The San Andreas fault is a right lateral strike-slip fault that trends northwest along the California coast. It is 13.5 to 14.5 miles from the project at its closest point. The San Andreas fault is capable of producing a maximum credible earthquake (MCE) of magnitude 8.3, equivalent to the great earthquake it produced on 18 April 1906, centered approximately 24 miles northwest of San Francisco, California. On 17 October 1989 the southern Santa Cruz Mountains Segment of the San Andreas fault experienced a magnitude 7.1 earthquake. The Hayward fault is also right lateral strike-slip fault, a part of the San Andreas fault system, that nearly parallels the San Andreas fault. The Hayward fault is capable of producing major earthquakes and lies 3.5 to 4.5 miles northeast of the project at its closest point. It is considered capable of producing a MCE in the range of magnitude 7.0 to 7.5. Two historic events attributed to the Hayward fault occurred in June 1836 and October 1868; both have been assigned a magnitude 7.0 ± 0.5.

The probability of large earthquakes in the San Francisco Bay region was addressed by the Working Group on California Earthquake Probabilities, and the results of their study and recommendations were published in U.S.G.S. Circular 1053 (1990). Their study centered on the San Andreas fault, Hayward fault, and the Rodgers Creek fault. The San Andreas fault subdivided into segments by the Working Group and each segment was assigned a probability for an earthquake magnitude (M) equal to or exceeding M7 occurring within the 30 year period beginning with 1990. Those segments near and within the San Francisco Bay region that have been assigned a probability of producing an earthquake of $M \geq 7$ are as follows: San Francisco Peninsula Segment, extending northward from the southern Santa Cruz Mountains segment to the northern end of Lower Crystal Springs Reservoir, was assigned a 23 percent chance within the 30 year period; and the North Coast Segment, extending northward from Lower Crystal Springs Reservoir to Cape Mendocino (This segment experienced the greatest amount of slip during the M8.3 San Francisco earthquake of 1906), was assigned a 2 percent chance of $M \geq 8$ during the 30 year period. The Working Group also subdivided the Hayward fault into two segments, the Northern and Southern East Bay segments. The Northern East Bay Segment, believed to have ruptured during the 1836 earthquake, was assigned a 28 percent chance $M \geq 7$ during the same 30 year period. The Southern East Bay Segment, believed to have ruptured in 1868, was assigned a 23 percent chance $M \geq 7$ during the same 30 year period. Should both segments rupture simultaneously the resulting seismic event could have a magnitude as large as M7.5. The Rodgers Creek fault, a right stepping offset continuation of the Hayward fault extending north-northwest from San Pablo Bay, is considered to be a separable segment and was assigned a 22 percent chance for the 30 year period. However, in April 1992, Mr. David Schwartz of the U.S.G.S. raised the probability of $M \geq 7$ on the Rodgers Creek fault to 35 percent during the next succeeding 30 years based upon field work studies including trenching

across the fault. The southern end of the Rodgers Creek fault lies approximately 14 miles from the Richmond Inner Harbor while the northern end of the San Francisco Peninsula Segment lies approximately 23.5 miles from the Inner Harbor.

A magnitude 7 or greater event on anyone of the previously mentioned segments would impart ground-motions severe enough to potentially cause massive slope failures in the low strength Younger Bay Mud and comparable steep cut slopes in the existing harbor area. Local slope failures are assumed to occur during moderate to strong earthquakes along these fault lines. According to a U.S.G.S. open file report, 82-1033 "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States" by S.T. Algermissen and others (1982), a 10 percent probability exists of exceeding a horizontal bedrock acceleration of approximately 0.53g in 50 years within the Richmond Inner Harbor area. Such an acceleration could be exceeded by a magnitude 7.5 event on the Hayward fault and equaled by an event of magnitude 6.5 to 6.8. Damaging strong ground-motions should be expected to affect the Richmond Harbor during its lifetime.

3. SOILS

The classification of soils within the Richmond Inner Harbor Deepening project was determined from review of historic records of sample gathering and boring logs. Subsurface soil sampling within the project area from October 1973 through February 1994 indicates that the materials to be dredged will range from dark gray silty clays of the Younger Bay Mud with localized sand lenses to brown, silty and sandy clays with minor lenses of silty to clayey sands, and to bluish gray to greenish gray, silty to sandy clays of Older Bay Mud (probably San Antonio equivalent) with minor lenses of silty to clayey sands. The silty clays of the Younger Bay Mud are generally very soft to soft, highly plastic, and have an average water content of 72 percent and a dry unit weight of 58 pounds per cubic foot (pcf) (see Figure 1). The localized sand lenses are silty and loose to medium dense. The brown clays are firm to stiff, range form sandy to silty, from low to high plasticity, and have an average water content of 31 percent and a dry unit weight of 91 pcf (Figure 2). The minor lenses of brown, silty to clayey sand are medium dense. The bluish gray clays of the Older Bay Mud range from firm to very stiff, from sandy to silty, and from high to low plasticity. They have an average water content of 27 percent and a dry unit weight 96 pcf (Figure 3). The minor lenses of silty to clayey sand are medium dense to dense. The Older Bay Mud is considered to have undergone preconsolidation.

In general the soils expected to be dredged from the project are distributed as described below. The Santa Fe Channel, at the northern end of the Richmond Inner Harbor, has been excavated into and is underlain by Older Bay Mud dark bluish gray to olive gray and in some instances greenish gray in color. Older Bay Mud also extends southwards underlying approximately 4,400 feet of the Inner Harbor Channel. A thin layer of

very soft, recently deposited Younger Bay Mud covers the bottom of both channels. Logs of borings performed by others for port development design near the southern end of the eastern side of the Inner Harbor Channel indicate that brown alluvial silts, clays, and some silty sand lenses were deposited on top of the Older Bay Muds. However, within the Inner Harbor Channel apparently all or most of the brown alluvial silts and clays have been removed; although, a 6-foot thick lens of medium dense, brown clayey sand is found at -42 feet MLLW at boring RI 86-9. Currently existing boring data indicates that the average elevation for the top of the stiff to very stiff clays in the Santa Fe Channel is -38.2 feet MLLW and -39.6 feet MLLW for the Inner Harbor Channel. However, 25 percent of the borings within the channel line of the Inner Harbor have elevations above -39.0 feet MLLW. This suggests that for these areas underlain by the Older Bay Mud the channel should be overdredged one foot for hard bottom plus an allowable one foot dredging tolerance.

Firm to stiff brown clays, probably alluvial orgin, are found underlying approximately 4,800 feet of the Potrero Reach Channel and lying immediately west of the center of the Potrero sharp turn. The brown clays gradually slope downward to beneath the -40 feet MLLW depth at the western end of this section. An occasional minor sand lens was detected by the borings in the channel area. The borings within this portion of the Potrero Reach Channel indicate the brown clays are covered by a thin layer of very soft to soft Younger Bay Mud. The existing boring data indicates that in this portion of the channel, the average elevation of the interface between the Younger Bay Mud and stiff to hard materials is -38.4 feet MLLW. Thus, suggesting that this portion of the channel be regarded has having a hard bottom requiring one foot of overdredge plus one foot of dredging tolerance. At the eastern end of the Potrero Reach Channel in the Potrero sharp turn the alluvial clays are in contact with an apparent old erosional ravine that is now filled with very soft to firm Younger Bay Mud.

The Younger Bay Mud filled ravine in the eastern half of the Potrero sharp turn occupies 1100 feet of channel, measured parallel to centerline, and is located between the alluvial brown clays of the Potrero Reach Channel and the Older Bay Mud of the Inner Harbor Channel. The ravine is bounded on the northwest by the bedrock of the San Pablo Hills. The bottom of the ravine exceeds -60 feet MLLW elevation at boring RI 86-7. The trend of the ravine is not known for certain, but is believed to trend south-southeast towards the eastern flank of Brooks Island.

The western portion of the Potrero Reach Channel, the Entrance Channel, and the transition from the Richmond Outer Harbor are all underlain by soft Younger Bay Mud.

4. BEDROCK

Bedrock has previously been excavated from two limited areas along the inside edge of the channel at Point Potrero in the mid-1950's to allow the

channel to be deepened to its current depth. The existing bedrock conditions, post 1950's excavation, was explored by five rock core borings and seven wash boring probes. Core recovery from the five core borings was very poor, averaging 38 percent. Bedrock in the western area was found at an elevation of -36.5 feet MLLW in boring 1F 86-1 and in the eastern area at elevation of -37.6 feet MLLW in boring 1F 86-4. Rock core borings in those two areas indicate that the bedrock is a graywacke sandstone with shale interbeds. The sandstone is closely to very closely fractured, highly weathered, and has been stained brown by the oxidation of iron boring minerals. The shale interbeds are very closely fractured and highly weathered. The bedrock in those two areas is relatively weak and is considered to be easily ripped. The bedrock can be easily excavated by a dipper bucket equipped with rock teeth or by a rotary cutting head suitably equipped with rock-cutting teeth. See Plates 10 through 11 for boring logs.

5. EXPLORATIONS

A total of 143 borings were performed within the Richmond Harbor area. The logs and laboratory test data were used to obtain a better understanding of the physical characteristics and extent of the materials that will be dredged. The borings consist of 41 borings performed for collecting samples to be used in geotechnical visual classification according to the Uniformed Soils Classification System, for environmental sediment quality testing, and for physical property testing at the South Pacific Division Laboratory (SPD Lab). An additional 12 borings were performed for locating and classifying a submerged and buried bedrock mass. Of those 12 borings, 5 were 4-inch diameter rock cores and 7 were wash boring probes. Ninety vibratory hammer borings that collected 4-inch diameter sediment cores were performed and logged for environmental quality analyses and characterization.

The intent of the soil exploration program for obtaining design soil properties was to keep cost down by using relevant data already available for the project area and to supplement that information to the extent necessary to obtain sufficient information to design and analyze the stability of the planned excavation slopes. In-house data search provided 29 overwater soil boring logs applicable to the project area. The borings were performed during the time period of 1973 through 1985 and are discussed in the following paragraphs.

Two borings, 2D-140 and 2D-141, were performed in October 1973 to a depth of -43.5 and -41.5 feet MLLW respectively as a part of the Carquines to Oakland Estuary exploration program. Continuous samples were taken using 2.12- inch i.d. plastic liners in 2.5-inch o.d. x 30 inches in length steel push tubes. In May 1974, nine borings, 2D-111, 112, 113, 117, 118, 121, 123, and 124 were performed to depths that ranged from -41.0 to -46.5 feet MLLW. Samples were taken continuously by 2.12-inch i.d. plastic liners in steel push tubes in the soft clays and by driving the plastic lined tubes using a 140 pound drive hammer.

From August 1976 through July 1981 only three borings, 2D-138, 2D-139, and 2D-204, of several O&M sampling locations revealed any information concerning materials that are anticipated to be dredged. Of the three sample locations, two are borings that used 2.12-inch i.d. plastic lined steel sample tubes and the third was a push tube sample taken by a diver. The sampling depths ranged from -37 to -38 feet MLLW.

In 1983, seven borings were performed just outside of the Potrero Channel for the purpose of determining foundation conditions below the Richmond Training Wall. These borings, RT 83-1 through RT 83-7, were sampled by means of 3-inch o.d. Shelby tube samples on 20-foot centers, and by continuous 2-inch o.d. split-spoon samples in the intervening intervals. The split-spoon samples were classified and logged in the field and then discarded. The borings penetrated to depths that ranged from -83.4 to -96.5 feet MLLW.

In 1985, borings were performed for the planned deepening of the Long Wharf Maneuvering Area. One of those borings, RO 85-6, was drilled at the beginning of the Harbor Entrance Channel and reached a depth of -69.0 feet MLLW. In September of 1985, seven piston drop core borings were performed in the project area as a part of a dredge disposal study. The piston drop core sampling device had a 3-inch o.d. sampling barrel that was 15 feet in length and contained a 2.5-inch i.d. plastic liner. The drop cores reached depths that ranged from -22.8 feet MLLW at RI-6 to -42.2 feet MLLW at RI-4 and -42.1 feet MLLW at RI-3.

The existing data was supplemented in 1986 by twelve borings performed specifically for the Harbor Deepening project. In January 1986, twelve borings, RI 86-1 through RI 86-12, were accomplished in the project area to depths that ranged from -45 feet to -60.8 feet MLLW. These twelve borings were sampled continuously for the first 9 feet and then on 6-foot centers, except for borings RI 86-8 and RI 86-12. Those two borings were sampled continuously for the first 30 feet and then on 6-foot centers to the bottom of the boring. The sampling was performed using an Osterberg piston sampler containing 3-inch o.d. Shelby tubes for the soft to firm clays. The denser sands and stiff clays were sampled using 3-inch o.d. modified California or a Sprague-Henwood drive samplers. The drive sampler were driven using a 345 pound down hole, wire-line hammer falling 30 inches.

Although it was known that some bedrock removal had been performed along the inner portion of the Potrero sharp turn at Potrero Point no rock cores or descriptions were found. Therefore, exploration rock core borings and wash boring probes were undertaken in January 1986 to remedy the situation. Bedrock locations were explored using a 3-inch i.d. Pitcher Barrel and a conventional 4-inch i.d. diamond coring bit with a double tube core barrel. Five core holes were drilled to depths that ranged from -53.6 feet to -56.0 feet MLLW and penetrated an average of 14.9 feet into rock. Average recovery was 38 percent. To help delineate the extent of bedrock, seven probe borings, P-1 through P-7, were performed. Each probe

penetrated top of rock at least two feet or stopped at a drilled depth of 22 feet if rock was not reached. Bedrock was encountered in all but one probe, P-3, which bottomed out at -57 feet MLLW. For logs of the rock core borings and rock probes see the attached Plates 10 through 11 on 8 1/2-inch x 11-inch sheets.

Subsequent to the 1986 exploration program sediment core samples were collected by the Environmental Branch of the San Francisco District for the purpose of environmental quality analyses and characterization relating to the disposal of the proposed dredge material. Between 1991 and 1994, ninety vibratory hammer core boring locations were sampled within the currently designated project area. Twenty-five of these borings were contracted by EPA for the United Heckathom Superfund Site. The vibratory hammer sediment cores of 4-inch diameter were collected and logged by Battelle Memorial Institute of Pacific Northwest Laboratory, Sequim, Washington. The cores generally penetrated as deep as -42 feet MLLW and were viewed and used to better determine the horizontal extent of the material to be dredged. The logs of these borings are presented on 8 1/2-inch x 11-inch sheets in Attachment G to the Geotechnical Section. Of the ninety borings 24 percent are in the Santa Fe Channel area, 32 percent in the Inner Channel area, and 36 percent in the Potrero Reach Channel and Potrero Point sharp turn area. The remaining 8 percent are distributed over the western end of the Potrero Reach Channel and the Entrance Channel.

Also subsequent to the 1986 exploration program, the turning circle area was relocated and the project extended approximately 2,100 feet up the Santa Fe Channel. The turning circle area was moved from a proposed location at the northeast exit from the Potrero Point sharp turn area to the outside corner of the Potrero Point sharp turn, much closer to the bedrock outcrop of Brooks Island. These changes were made without further subsurface geotechnical investigation. However, in December 1995 additional geotechnical exploration borings are to be undertaken to investigate the physical properties of the stiff soils underlying the Santa Fe Channel and the soils underlying the new turning circle location, and to further investigate and delineate the contact between soft and stiff soil in the Potrero Point sharp turn and in the Inner Harbor. Laboratory testing on the stiff soil is planned to be accomplished at the SPD Lab with regards to better determining dredgability.

6. LABORATORY TESTING

The laboratory test results are shown on the boring logs. Some of the October 1973 boring samples were subjected to laboratory tests consisting of mechanical analysis and moisture contents. Borings performed from May 1974 through July 1981 were subjected to environmental sediment quality testing, no record of testing by the SPD soils laboratory was found. The laboratory test results for RT 83-1 through 7 for samples at and above -45 feet MLLW are shown on the boring logs. The laboratory tests consisted of grain-size analyses, Atterberg limits, moisture contents and dry unit

weights. In addition some shear strength testing was performed. The shear strength tests consisted of eight unconsolidated, undrained, triaxial compression tests (UU test), four unconfined compression tests (UC test), and one consolidated, undrained, triaxial compression tests (CU test). The samples from RO 85-6 were subjected to laboratory tests consisting of grain-size analyses, Atterberg limits, moisture contents, and a few dry unit weights for those samples that underwent triaxial compression testing. Shear strength testing consisted of four laboratory vane shear tests (LVS test) and three UU tests. Some of the piston drop core samples underwent grain-size analyses, Atterberg limits, and moisture contents. Only those samples that underwent triaxial compression testing had their dry unit weights determined. The shear strength testing consisted of eight LVS tests and three UU tests. The samples from borings RI 86-1 through 12 underwent grain-size analyses, Atterberg limits, moisture contents, and dry unit weights to accompany triaxial compression testing. Shear strength testing consisted of 28 LVS tests and 21 UU tests. The LVS tests were conducted in soft to firm clays and UU tests were conducted on samples of firm to very stiff clays. All testing was conducted at the South Pacific Division Laboratory. The results of laboratory testing are included in Attachments A through F to this appendix.

7. LIQUEFACTION

Liquefaction results when a saturated sand is subjected to ground vibrations such as those occurring during an earthquake. The ground motions or vibrations tend to cause the sand to densify by decreasing the volume of the interstitial voids. As the sand densifies part of the water that occupies the voids is forced out. If drainage occurs at a slower rate than at which water is being forced out of the voids, water pressure in the voids or pore spaces increases. If the pore water pressure builds up to a point that is equal to or greater than the pressure exerted by the weight of the overlying material, the effective stress due to the overburden becomes zero. The sand then loses all of its strength and develops a liquefied state.

It can be expected that some of the lenses of loose sand in the Younger Bay Mud that may be encountered in the excavation of the turning basin could liquefy due to the influence of a moderate seismic event on the Hayward fault or a stronger event on the San Andreas fault close to the project. Boring RI 86-8 along with vibratory hammer cores TB-2, TB-3, and TC-7 indicate that a clayey sand layer upwards of 2 feet in thickness will be intersected during the construction of the turning circle. Boring RI 86-8 indicates than an additional thickness of 6 feet of silty sand will be encountered. These sand layers could possibly lend themselves to liquefaction, resulting in lateral deformation and flow failure of the slope. It can also be expected that loose sand lenses in the Younger Bay Mud and in the fill under some of the existing structures will liquefy and result in some lateral movement towards the channel should they be saturated at the time a moderate to strong seismic event occurs on the Hayward fault close to the project.

8. SLOPE STABILITY

Richmond Harbor Channel. The shear strengths of Younger Bay Mud obtained from laboratory testing were reviewed in order to provided appropriate strength parameters for slope stability analyses. The generally used 1 vertical to 3 horizontal (1V:3H) side slopes for Corps of Engineers dredging projects within the San Francisco Bay were analyzed for this project. The side slopes stability analyses were performed using the Corps of Engineers UTEXAS3 Slope Stability package. The side slopes found to be the most critical are those to be constructed in the proposed turning basin area where the elevation of the top of slope approaches -4 feet MLLW. The slopes were analyzed for a condition of a 36-foot cut in Younger Bay Mud approximately 60 feet thick and underlain by stiff to very stiff clay (see Figure 4). It was found that a 1V:3H slope will have a static factor of safety of approximately 1.6. The slope was analyzed for horizontal seismic loading using the pseudostatic portion of the program. It was found that the slope will have a factor of safety of 1.03 with a seismic coefficient of 0.05. Borings in the turning basin area also indicated the possibility of having a lense of non-plastic, medium dense silty sand at or above the toe of the excavated slope. The slope was reanalyzed for the condition of approximate 60-foot thick layer of soft Younger Bay Mud with a 10-foot thick layer of medium dense silty sand at the toe. It was found that the slope will still have a static factor of safety greater than 1.5 and that a seismic coefficient of 0.05 produced a factor of safety of 1.02. The sand was assigned a phi angle of 32 degrees and a wet unit weight of 130 pounds per cubic foot.

Side slopes of 1V:3H are recommended for the Phase I Richmond Harbor Deepening. However, it must be noted that the recommended side slopes will provided only minor seismic stability. Slope failures may be expected for moderate and stronger seismic events close to the project. Although a stability analysis has not been performed for an excavated bedrock slope, it is recommended that the slope be flatter than the near angle of repose of a 1V:1.5H slope. A slope of 1V:2H is recommended.

Santa Fe Channel. Slope stability analyses for a 1V:3H slope were run for the construction case and pseudo-static seismic case. Soil profiles and strength, parameters were developed from borings obtained during the January 1993 environmental sampling program. The Corps UTEXAS3 computer program was used. Spencer's method of analysis with the circular search was used to determine the minimum safety factor for the cases analyzed.

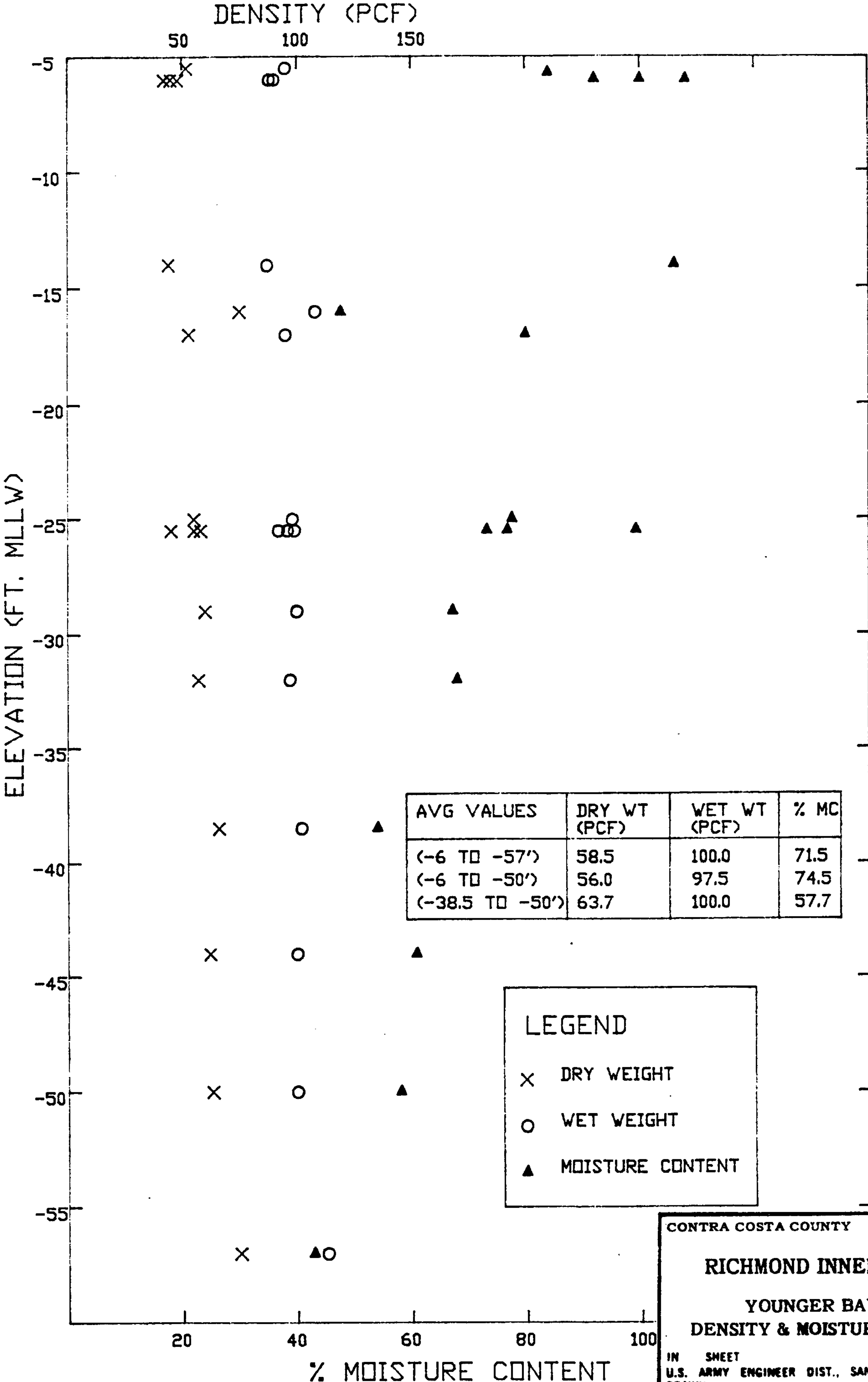
The safety factor for the after construction case is approximate 1.21. The safety factor for the pseudo-static seismic case is approximate 1.03 corresponding to a seismic coefficient of 0.03. Liquefiable soil doesn't appear to be a potential problem within this area, but there could be minor slope failure from strong earthquake shaking. This could lead to increased maintenance.

The boring logs for the reach are shown in Appendix A, Plate 12. The results of the slope stability analyses are shown in Figure 5, Appendix B.

9. <u>GROUNDWATER</u>. It is highly probable that in some areas salt water intrusion landward into the bedrock and sediments has already taken place. This is evidenced by the exposure of the bedrock at Point Potrero and the perimeter of Brooks Island, and by the existence of minor sand lenses between 0.0 MLLW and -35 feet MLLW that obviously have been transected during historic harbor construction. The bedrock was exposed during the construction of dry dock facilities at Point Potrero and again during the mid-1950's when high areas of bedrock along the inside edge of the channel in the Potrero wide turn area were removed to elevation of -37 $\pm$ feet MLLW. Borings by others along the channel of the Richmond Inner Harbor indicate that minor sand lenses in the brown clays and Younger Bay Mud occur between 0.0 MLLW and -35 feet MLLW. The sand lenses project to the very edge of the channel. Although it is not known if the sand lenses are connected to any specific fresh water aquifer, it can be assumed that those lenses have been contaminated by salt water.

As indicated by the boring logs a few sand lenses will be intersected. The brown clayey sand layer of boring RI 86-9 will be intersected by the channel deepening but it does not appear to have any significant horizontal extent. A 3-foot thick lens of greenish gray silty sand within the Older Bay Mud occurs at approximately -45.5 feet MLLW in a boring by others near the southern end of Terminal 3. Since the sand layer in RT 86-9 appears to be a remnant of probable brown clayey alluvial deposits it cannot be correlated with a sand layer deposited in an older formation. Whether or not there is a physical contact at an erosional surface is unknown. The sand lenses in the Younger Bay Mud that may be excavated during the dredging of the turning basin appear to have limited horizontal extent. The sand layers at borings TB-2, RI 86-8, TB-3 and TC-7 do not show in boring TB-4 and appear not to be connected with the thin clayey sand layers in TC-1, TB-7, TC-2, and TC-3 which are higher in elevation and probably more recent in age. The sand lens being geologically recent deposition in a marine environment and of probable limited extent are unlikely to sources of fresh water.

It is concluded based upon the borings as shown on the boring location maps (Plates 1 through 4) that no major groundwater aquifer will be intersected or directly exposed to salt water intrusion by the deepening of the Inner Harbor Channel. However, the possibility that some of the sand lenses that may intersected or uncovered during the dredging may contain fresh water cannot be ruled out.



AVG VALUES	DRY WT (PCF)	WET WT (PCF)	% MC
(-6 TO -57')	58.5	100.0	71.5
(-6 TO -50')	56.0	97.5	74.5
(-38.5 TO -50')	63.7	100.0	57.7

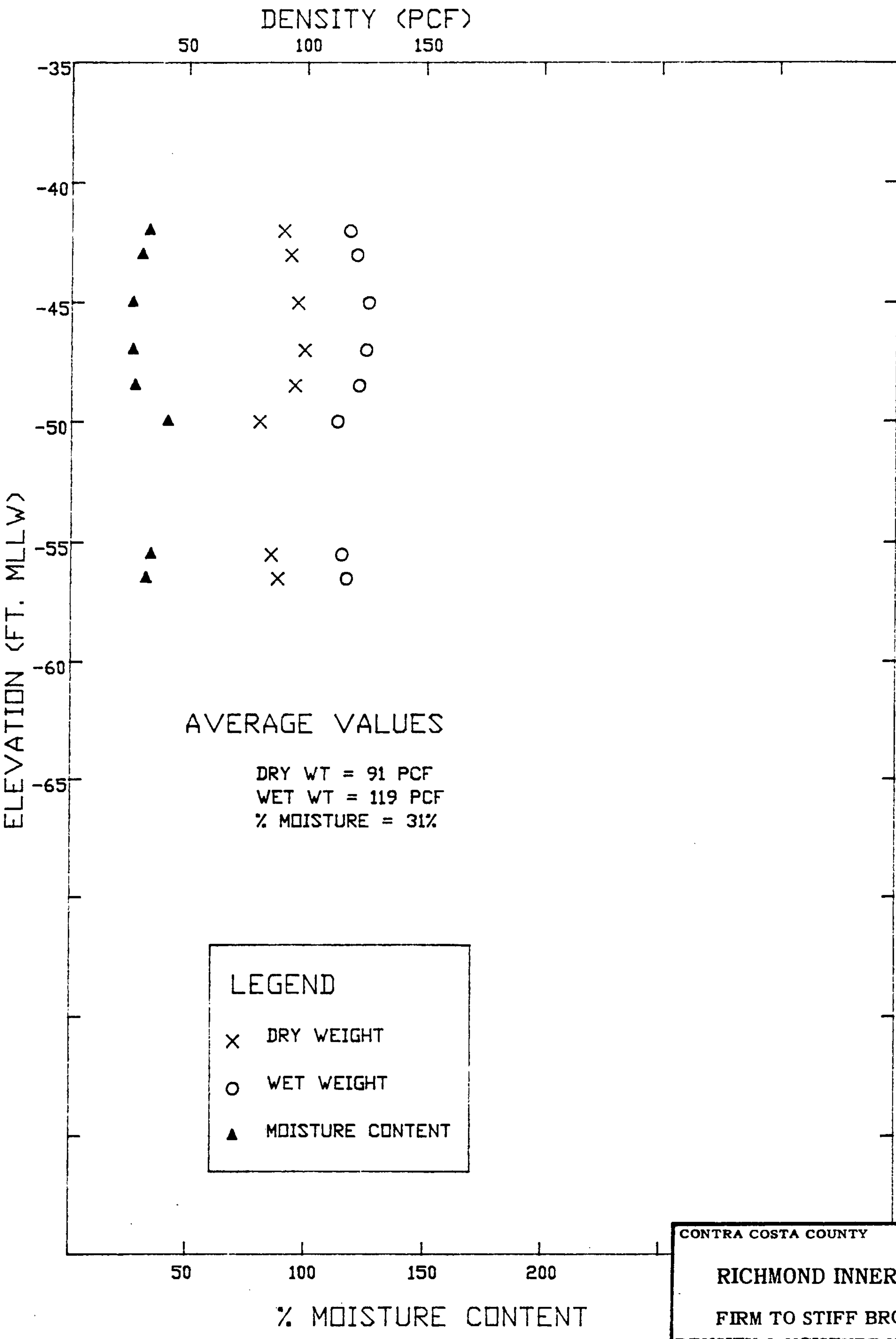
CONTRA COSTA COUNTY CALIFORNIA

RICHMOND INNER HARBOR

YOUNGER BAY MUD
DENSITY & MOISTURE VS. DEPTH

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: DATED

APPENDIX A ~~B~~ FIGURE 1



CONTRA COSTA COUNTY CALIFORNIA

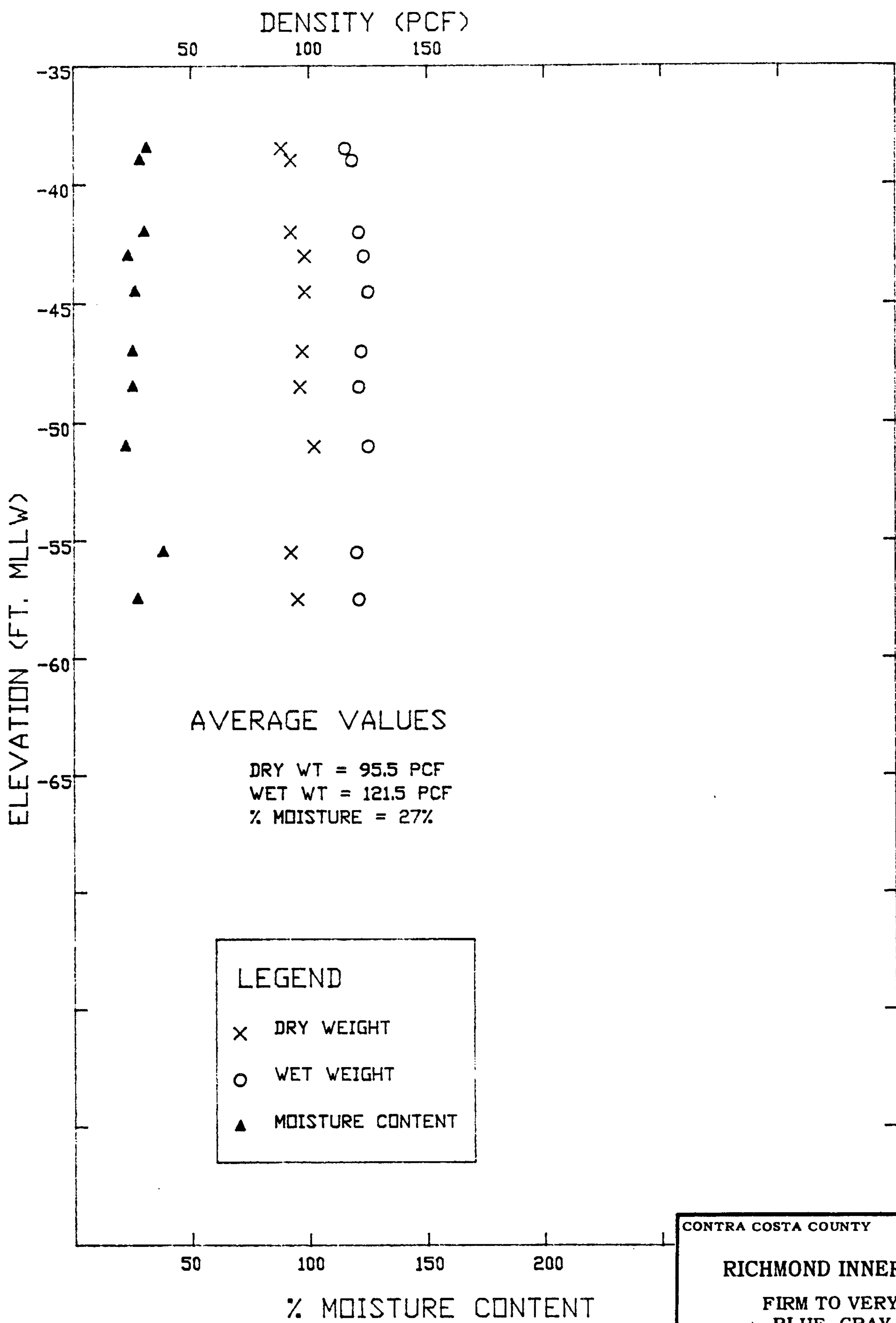
RICHMOND INNER HARBOR

FIRM TO STIFF BROWN CLAY

DENSITY & MOISTURE VS. ELEVATION

IN SHEET	SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E	
DRAWN:	FILE NO.
TRACED:	TO ACCOMPANY REPORT
CHECKED:	DATED

APPENDIX A FIGURE 2



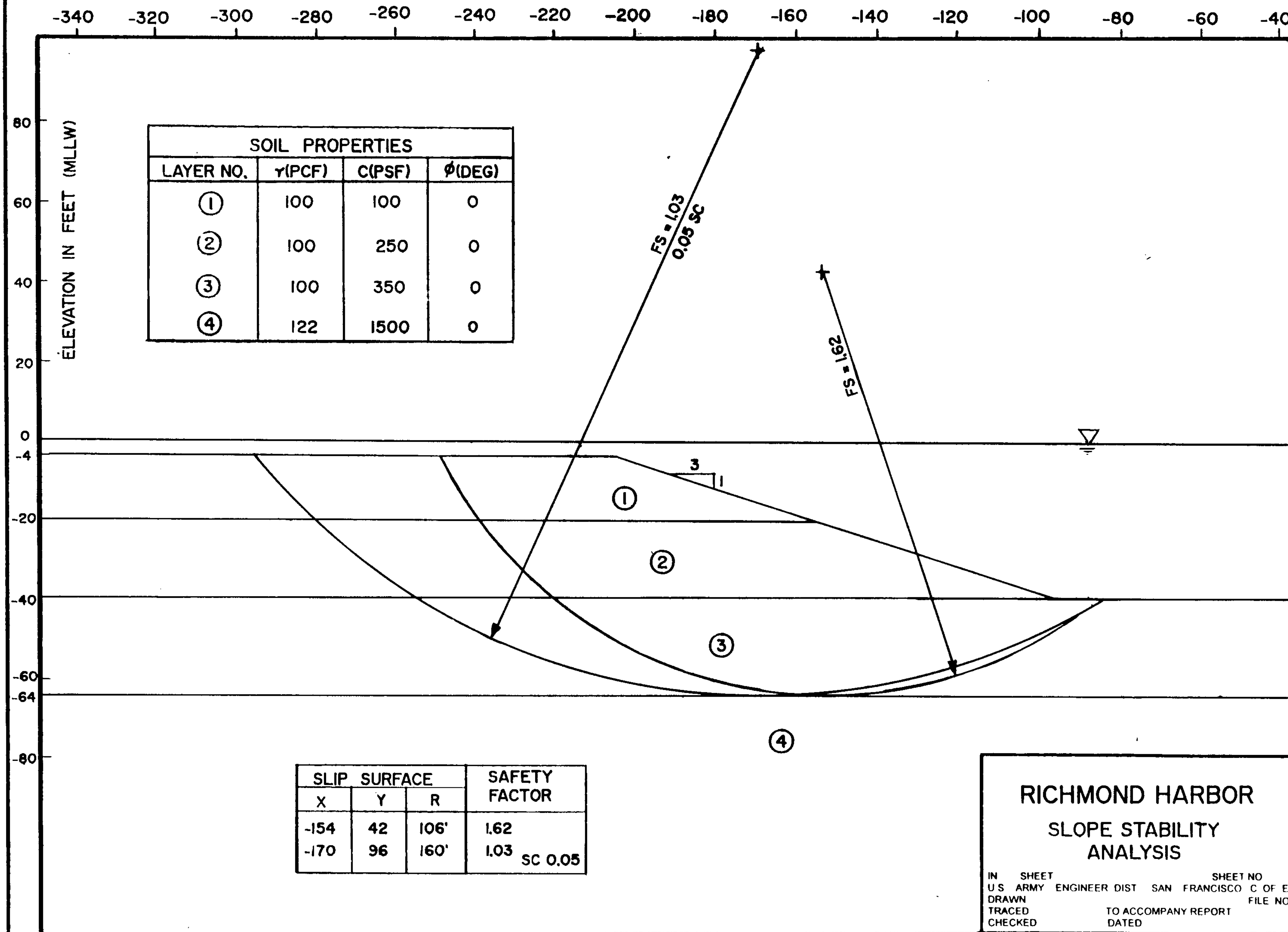
CONTRA COSTA COUNTY CALIFORNIA

RICHMOND INNER HARBOR

FIRM TO VERY STIFF
BLUE–GRAY CLAY
DENSITY & MOISTURE VS. ELEVATION

IN SHEET SHEET NO.
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN FILE NO.
TRACED TO ACCOMPANY REPORT
CHECKED DATED

APPENDIX A FIGURE 3



SOIL PROPERTIES			
LAYER NO.	γ(PCF)	C(PSF)	φ(DEG)
1	100	100	0
2	100	250	0
3	100	350	0
4	122	1500	0

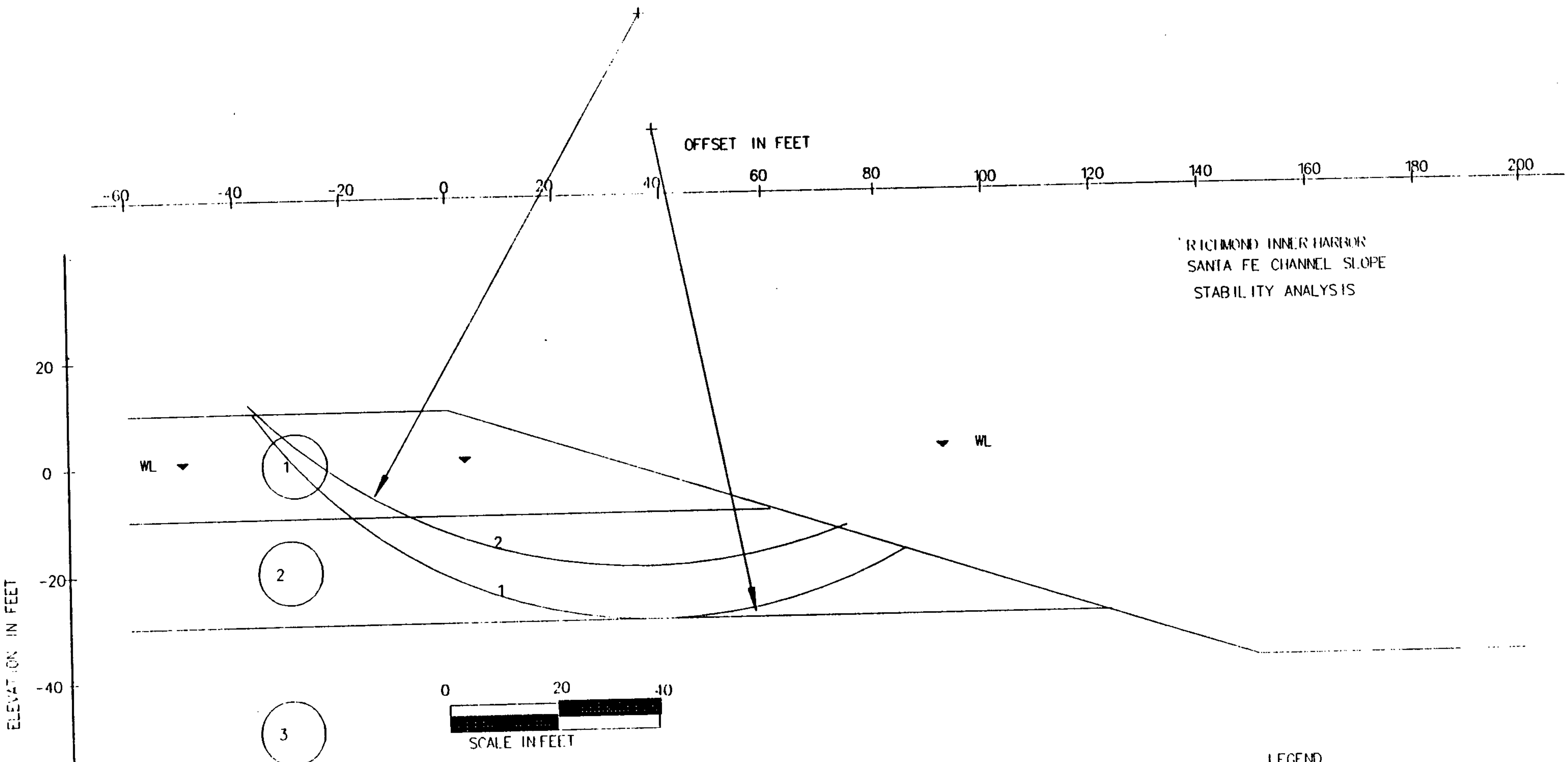
SLIP SURFACE			SAFETY FACTOR
X	Y	R	
-154	42	106'	1.62
-170	96	160'	1.03 SC 0.05

RICHMOND HARBOR

SLOPE STABILITY ANALYSIS

IN SHEET SHEET NO
U S ARMY ENGINEER DIST SAN FRANCISCO C OF E
DRAWN FILE NO
TRACED TO ACCOMPANY REPORT
CHECKED DATED

APP. A FIG. 4



SOIL PROPERTIES				PROB.	SLIP SURFACE				SAFETY
LAYER NO.	γ_t (PCF)	c (PSF)	ϕ (DEG)	NO.	X Y	RAD			FACTOR
1	110	450	0	1	39 62	92			1.21
2	105	350	0	2	37 74	104			1.03 .03 SC
3	115	1000	0						

LEGEND

WL WATER LEVEL
SC SEISMIC COEFFICIENT

APPENDIX ~~B~~ A FIGURE 5

RICHMOND HARBOR DEEPENING

SEDIMENT CORE LOGS
OF
VIBRATORY HAMMER CORE SAMPLES

COLLECTED AND LOGGED BY: BATTETTE / MARINE SCIENCE

LABORATOR, BATTETLLE MEMORIAL INSTITUTE,

SEQUIM, WASHINGTON

ATTACHMENT G

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: SB-1 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 2

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-17.1	0														Upper 1 ft. of core missing
-18.1	1		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	VFS	N		
							(wood is black)						P N		decayed wood
												Z			
	5														
							2.5YN2/ black						P	Berth 6A/B Maintenance	gas holes
-27	9.9														
												VFS			
													strong P	Berth 6A/B Deepening	oily appearance
								S							oily spot

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: SB-1 *Logger:* PJ White *Date:* 2-10-94 *Page* 2 *of* 2

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	15		R	M	M	CL	2.5YN2/ black	S	N	H	N	VFS	P	Berth 6A/B Deepening	
-33.9	16.8		NA	NA	NA	siltstone	10YR5/8 yellowish brown	H	W/M	S	N	Z	N		YBM } mixture of YBM/rock Layers of cemented but highly fractured hard rock. Fracture surfaces coated with iron oxides. Very hard & dry, highly weathered
-35.6	18.5														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: SB-2 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-22.1	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	FS	N	Berth 6A/B Maintenance	
												VFS			
												FS Z			gas holes
	5						2.5YN2/ black					FS	P		
								S				Z	N		
												FS	P		oily appearance
-32.7	10.6		NA	NA	NA	sand, clay, siltstone	10YR5/8 yellowish brown	H	W/M	S	N	MS	N		YBM
-34	11.9													Berth 6A/B Deepening	Highly fractured, layered sand, siltstone, clay.
-35.3	13.2														Highly weathered and altered by iron oxides

DRAFT-PRMD

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: SB-3 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-26.3	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	FS-Z	N	Berth 6C/D Maintenance	few gas holes
	5						2.5YN2/ black					FS			
			NA	NA	NA		5Y4/1 dk gray	S				Z			sharp contact between VS black clay & S drier gray clay
-37	10.7													Berth 6C/D Deepening	
-40	13.7														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: SB-4 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-28.6	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	VFS	N	Berth 6C/D Maintenance	
															gas holes
							2.5YN2/ black						P N		
	5												P N		mixture of VS black & S gray clay 5 ft - 6 ft
			NA	NA	NA		5Y4/1 dk gray	S				Z			All S gray clay below 6 ft
-37	8.4													Berth 6C/D Deepening	
-40	11.4														Lithology from 11.4 - 14 ft same as 6 - 11.4 ft

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: SB-5 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-28.1	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N → Z	VFS	N	Berth 7 Maintenance	
	5														gas holes
							2.5YN2/ black						P – N		
-37	8.9						5Y3/1 v. dark gray							Berth 7 Deepening	
							(black layer)						P – N		shell
															shell
-40	11.9														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: SB-6 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-30.1	0		R	M	M	CL → SP-CL	5Y3/1 v. dark gray	VS	N	H	N	FS → VFS → MS-Z	N	Berth 7 Maintenance	
-37	6.9						2.5YN2/ black → 5Y3/1 v. dark gray					FS → Z	P → N	Berth 7 Deepening	
-39.4	9.3		NA	NA	NA	CL	5Y5/2 olive gray - 5Y5/1 gray - 5Y5/2 olive gray	H	N	H	N	Z	N	Archive OBM	YBM / OBM
-40	9.9														
-42	11.9														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: MB-1 | *Logger:* PJ White | *Date:* 2-10-94 | *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.8	0		R	M	M	CL	5Y4/1 dk gray ↓ 5Y3/1 v. dark gray	VS	N	H	N	VFS ↓ FS	N	Arco Maintenance	
-38	3.2						2.5YN2/ black					Z	P N	Arco Deepening	YBM
			NA	NA	NA	GW ML	2.5Y5/4 lt olive brown	F	N	S	N	1 in. Z	N		gravel OBM
-40	5.2					GW CL GW SP ML CL		H				0.5 in. Z 0.5 in. MS Z		Archive OBM	grades from sand to clay
-42	7.2														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: MB-2 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.4	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	FS ↓ VFS	N	Arco Maintenance	
-38	1.6													Arco Deepening	
-39.4	3		NA	NA	NA	ML	5Y4/1 dk gray	F – H	N	H	N	FS – Z	N		YBM / OBM
-40	3.6													Archive OBM	grades to finer grain size
-42	5.6														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: MB-3 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-29.5	0		R	M	M	CL	5Y3/1 v. dark gray → 2.5YN2/ black	VS → S	N	H	N	VFS	N → P → N	Terminal 3 Maintenance	gas holes
	5														
-37	7.5		NA	NA	NA	ML → CL	5Y4/1 dk gray	F → H	N	H	N	Z	N	Terminal 3 Deepening	YBM / OBM; mixture of YBM/OBM; patches of whitish alteration calcite
-40	10.5														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: MB-4 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-33.5	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	FS → VFS	N	Terminal 3 Maintenance	gas holes
-37	3.5						2.5YN2/ black						P	Terminal 3 Deepening	wood fibers - piling?
							5Y3/1 v. dark gray						N		
-40	6.5														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: MB-5 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-33.1	0		R	M	M	CL	5Y3/1 v. dark gray → 2.5YN2/ black	VS → S	N	H	N	VFS → FS	N	Terminal 2 Maintenance	
-37	3.9		NA	NA	NA	ML	5Y4/2 dark grayish brown	F	N	H	N	Z	N	Terminal 2 Deepening	
-40	6.9							H → F				FS		Archive OBM	
-42	8.9														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: MB-6 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-33.2	0		R	M	M	CL	5Y3/1 v. dark gray ↓ 2.5YN2/ black	VS	N	H	N	FS	N ↓ strong P	Terminal 2 Maintenance	
-37	3.8						5Y3/1 v. dark gray						N	Terminal 2 Deepening	
-38.4	5.2		NA	NA	NA	ML	5Y4/1 dk gray	F ↓ H	N	H	N	Z	N		YBM / OBM
-40	6.8													Archive OBM	
-42															

DRAFT-PRMD

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: NB-1 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.4	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	VFS	N	Time Oil Maintenance	flat black worm?
-38	2.6	λ										FS – Z – FS		Time Oil Deepening	root
-40	4.6						2.5YN2/ black	S							root
-40.9	5.5	λ													

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: NB-2 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.3	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	VFS	N	Time Oil Maintenance	
-38	2.7						2.5YN2/ black	S				FS		Time Oil Deepening	
-39.3	4		NA	NA	NA	ML	5Y3/1 v. dark gray	F	N	H	N	VFS	N		YBM / OBM
-40	4.7													Archive OBM	whitish alteration - calcite
-41.8	6.5					SC						FS			

DRAFT-PRMD

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: NB-3 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.9	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	FS → VFS → FS	P N	Levin Maintenance	
-41	4.1						2.5YN2/ black						P		gas holes, mussel shells
															No Levin Deepening Sample

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: NB-4 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.0	0		R	M	M	CL	5Y3/1 v. dark gray	VS	N	H	N	FS	N	Levin Maintenance	
-38.7	2.7		NA	NA	NA	ML	5Y3/1 v. dark gray	H	N	H	N	VFS	N		YBM OBM few pieces of plant matter
-41.0	5														No Levin Deepening Sample

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: NB-5 *Logger:* PJ White *Date:* 2-8-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-32.7	0		R	M	M	CL	5Y2.5/1 black	VS	N	H	N	FS VFS	N	Texaco Maintenance	worm
-36.5	3.8		NA	NA	NA	ML	5Y3/1 v. dark gray	H	N	H	N	FS Z	N		YBM 2 in. below OBM contact altered brownish
-37	4.3													Texaco Deepening	
-40	7.3													Archive OBM	
-42	9.3														9.3 - 9.5 ft Not logged - same lithology

Core Data Log

Project: Port of Richmond Maintenance and Deepening Program

Core #: NB-6 *Logger:* PJ White *Date:* 2-8-94 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.2	0		R	M	M	CL	2.5YN2/ black	VS	N	H	N	FS	P	Texaco Maintenance	wood fragments (pilings?)
-37	1.8													Texaco Deepening	shells clast of OBM in YBM
															YBM OBM
-40	4.8		NA	NA	NA	ML	5Y3/1 v. dark gray	S	N	H	N	FS	N		mixture of OBM & YBM
-40.5								F H				Z		Archive OBM	not sampled because YBM mixed in
-42	6.8														

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: SF-1 *Logger:* PJ White *Date:* 2-9-94

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-38.5	0		R	M	M	CL	5Y3/1 v dk gray	VS	N	H	N	FS	N	Sed Chem	YBM
			NA	NA	NA	ML	5Y4/1 dk gray	H	N	H	N	VFS	N		OBM
40	1.5													Sed Chem	Patches of white alteration - calcite
-42	3.5														

Core Data Log

Core #: C-1 | Logger: Bjornstad/Cadoret | Date: 6/24/91 | Page 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.4	0		S	M	M	CL	5Y3/2, dark olive gray 5Y2.5/1, black 5Y3/2 dark olive gray	VS	N	H	N	FS	S w/ HCl	All YBM
38.0							5Y2.5/1 black			M				Shell fragments
40.0							5Y3/2 dark olive gray			H			Weak S w/ HCl	Shell fragments
40.6										S S		Sil[illegible] in sand strata)		Sand layers 1 cm thick
	5													
	10													
	15													

Composite chemistry samples

Core Data Log

Core #: C-3 *Logger:* Bjornstad/Cadoret *Date:* 6/24/91

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.0	0		S	L	M	CL	5Y4/1 dark gray ↓ 5Y3/2 dark olive gray	VS	N	H	N	FS Silt ↓ FS	S w/ HCl	All YBM; Gas voids; Composite chemistry samples
38.0														
39.6														
	5													
	10													
	15													

Core Data Log

Core #: C-5 *Logger:* Cadoret *Date:* 6/24/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.4	0		R	L	M	CL	5Y4/1 dark gray → 5Y3/1 very dark gray	VS	N	H → M → H	N	FS → VFS	S w/ HCl	All YBM; Composite chemistry samples
38.0														
39.7														
	5													
	10													
	15													

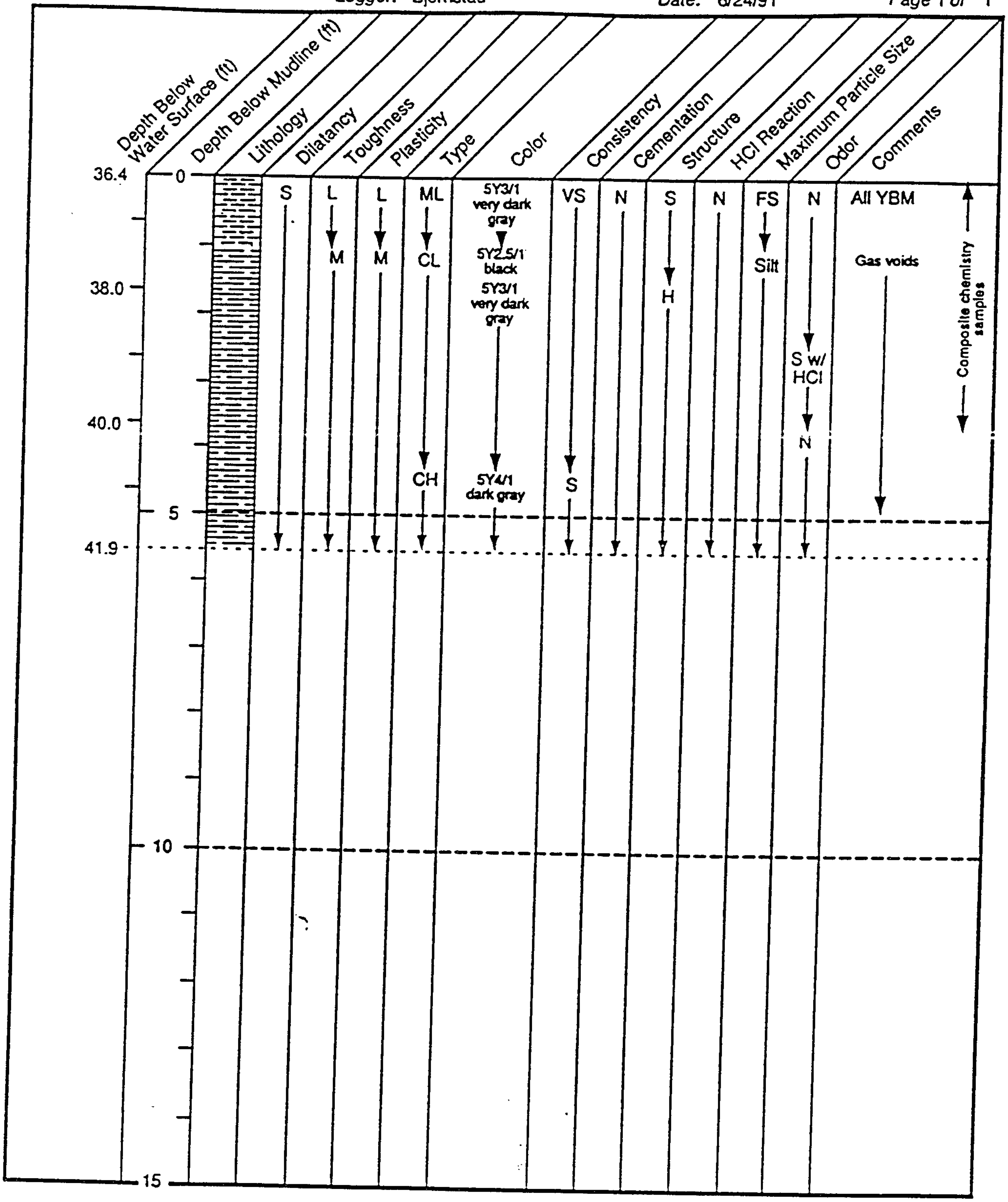
Core Data Log

Core #: C-6 *Logger:* Cadoret *Date:* 6/24/91

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.3	0		R	L	M	CL	5Y4/1 dark gray 5Y3/1 very dark gray 5Y2.5/1, black 5Y3/1 very dark gray	VS	N	H	N	VFS	S w/ HCl	All YBM Gas voids Preserved root? Composite chemistry samples
38.0														
40.0						CL/SP	5Y2.5/1, black 5Y3/1 very dark gray	S		L		FS		Laminated ML & SP, Laminae ≤ 1mm, possibly cross laminated
41.0														
	5													
	10													
	15													

Core Data Log

Core #: C-8 *Logger:* Bjornstad *Date:* 6/24/91 *Page* 1 *of* 1



Core Data Log

Core #: C-10 *Logger:* Bjornstad *Date:* 6/24/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.0	0		S	L	L	ML	5Y4/2 olive gray	VS	N	H	N	FS	N	All YBM
				M	M	CL	5Y2.5/1 black					Silt		Gas voids
38.0														High dry strength
													S w/ HCl	Composite chemistry samples
													N	
40.0			NA	NA	NA	SM	5Y4/1 dark gray	S				FS		
40.6														
	5													
	10													
	15													

Core Data Log

Core #: C-11 *Logger:* Cadoret *Date:* 6/24/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
37.3	0		R	L	M	CL	5Y4/1 dark gray → 5Y3/1 very dark gray	VS	N	H	N	VFS	S w/ HCl	All YBM; Gas voids; Composite chemistry samples
38.0														
39.8														
	5													
	10													
	15													

Core Data Log

Core #: C-16 *Logger:* Bjornstad *Date:* 6/24/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.2	0		S	M	M	CL	5Y3/1 very dark gray	VS	N	H	N	FS	S w/ HCl	Composite chemistry samples
38.0														
			S	M	M	CH SC CH	5Y5/1, gray 2.5Y5/4 light olive brown	S F		S H		MS MP MS	N	YBM / OBM Black organic nodules Elongated pebbles Very high dry strength
40.0														
40.9														
	5													
	10													
	15													

Core Data Log

Core #: C-18 *Logger:* Cadoret *Date:* 6/24/91

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.1	0		R	L	M	CL	5Y4/1 dark gray ↓ 5Y3/1 very dark gray	VS	N	H	N	VFS	S w/ HCl	Composite chemistry samples
38.0			↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	YBM
			S/R	L/M	M/M	CL/ML	5Y3/1, very dark gray/ 5Y5/1, grey	S		M		G/Silt		OBM mottled with YBM
40.0		Fe	NA	NA	NA	SC/CL	10YR4/3, brown	F		S/L		MP	N	OBM iron oxide nodules and organics
40.4		Fe	S	M	M	CH	10YR5/3, brown			H		Silt		
	5													
	10													
	15													

Core Data Log

Core #: C-19 *Logger:* Bjornstad/Cadoret *Date:* 6/24/91

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
35.9	0		R	M	M	CL	5Y4/1 dark gray	VS	N	H	N	FS	S w/ HCl	Composite chemistry samples
							5Y3/1 very dark gray			M				
38.0			S	M	M	CH	10YR5/3 brown	F		H			N	YBM / OBM Oxidized
		Fe Fe												
40.0			NA	NA	NA	SM						MS		iron oxide nodules
40.9	5													
	10													
	15													

Core Data Log

Core #: C-20 *Logger:* Cadoret *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.2	0		R	L	M	CL	5Y4/1 dark gray	VS	N	H	N	VFS	S w/ HCl	Very little sand
							5Y3/1 very dark gray							High dry strength
38.0														Composite chemistry samples
														High dry strength
														YBM
40.0		Fe Fe Fe	NA	NA	NA	SM	5Y5/1, gray 5Y4/4, olive brown 10YR5/3, brown	F				VCS	N	OBM
														Iron oxide staining
40.5														
	5													
	10													
	15													

Core Data Log

Core #: C-23 *Logger:* Bjornstad *Date:* 6/25/91

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
32.8	0		S	L	L	CL	5Y4/1 dark gray	VS	N	H	N	Silt	N	All YBM; Composite chemistry samples
34.0													Weak S w/HCl	
							5Y2.5/1 black							
36.0			S	M	M	CH	5Y3/1 very dark gray	S					N	Very high dry strength
38.0	5													
39.7														Very high dry strength
	10													
	15													

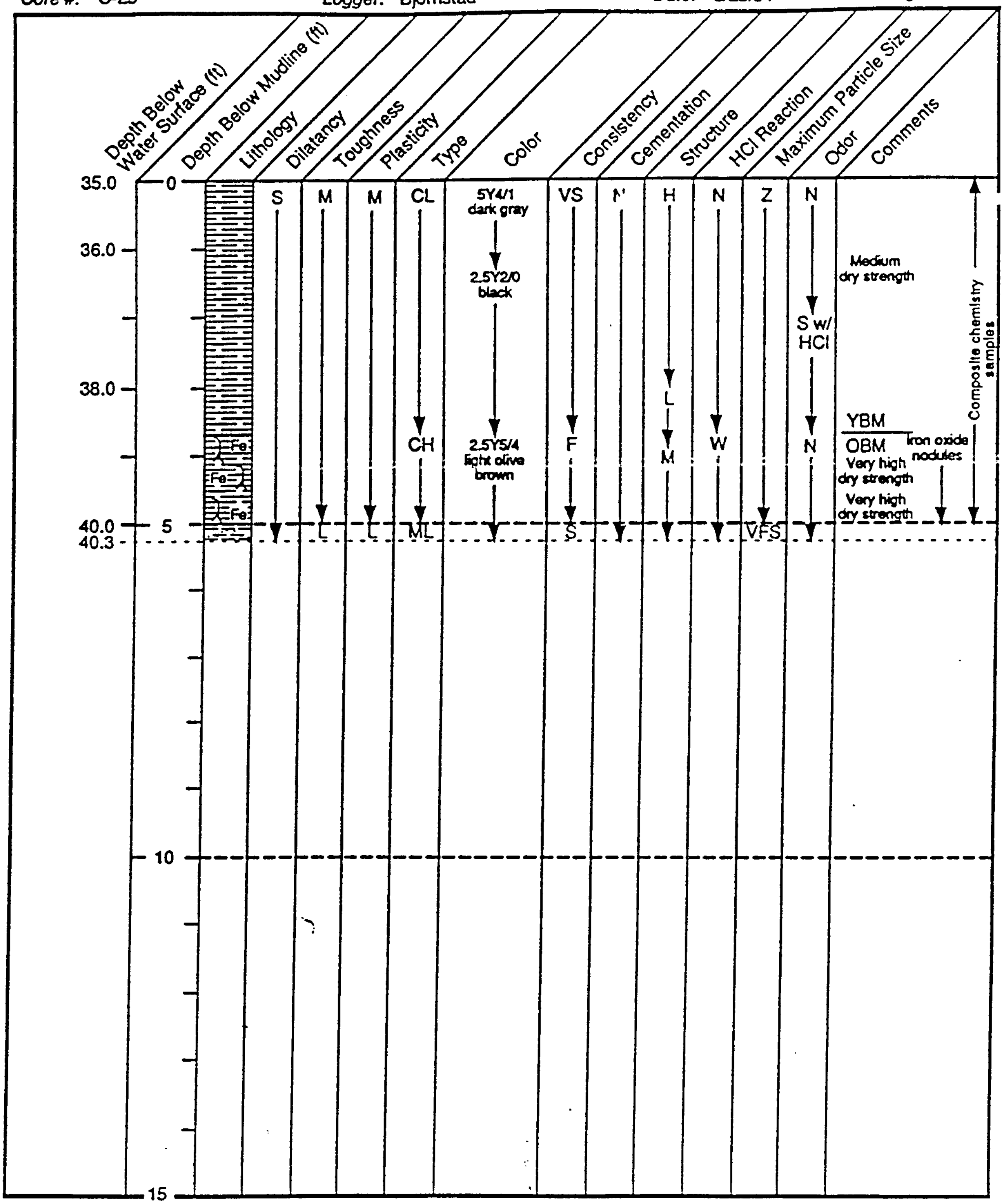
Core Data Log

Core #: C-24 *Logger:* Cadoret *Date:* 6/25/91

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.0	0		R	L	M	CL	5Y4/1 dark gray	VS	N	H	N	VFS	S w/ HCl	All YBM; High dry strength; Composite chemistry samples
							2.5YN3/0 very dark gray							
38.0			S	M			2.5YN4/0 dark gray	S				Silt	N	
							2.5YN3/0 very dark gray	VS				VFS	S w/HCl	High dry strength
							2.5YN4/0 dark gray	S				Silt	N	
							2.5YN3/0 very dark gray							Shell fragments
							2.5YN4/0 dark gray							High dry strength
40.0														
40.3														
	5													
	10													
	15													

Core Data Log

Core #: C-25 *Logger:* Bjornstad *Date:* 6/25/91 *Page* 1 *of* 1



Core Data Log

Core #: C-26 *Logger:* Bjornstad *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.1	0		S	M	M	CL	5Y4/2, dark grayish brown 5Y4/1 dark gray	VS	N	H	N	FS Silt	N	Composite chemistry samples
													S w/ HCl	High dry strength
38.0							5Y2.5/1 black							
														YRM
40.0			NA	NA	NA	SM SW	5GY4/1 dark greenish gray	S				FP MP	N	OBM Angular pebbles
40.6														
	5													
	10													
	15													

Core Data Log

Core #: C-29 *Logger:* Bjornstad *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
35.0	0		S	M	M	CL	5Y4/1, dark gray 2.5Y4/0 dark gray	VS	N	H	N	Silt	S w/ HCl	Composite chemistry samples
36.0														Gas voids
38.0						CH	5Y3/1, very dark gray, mottled with 5GY4/1	F		M	S			YBM / OBM Very high dry strength
							5GY4/1, dark greenish gray			H				Calcium carbonate nodules
40.0	5													Very high dry strength
45.5														
	10													
	15													

Core Data Log

Core #: C-30 *Logger:* Cadoret *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
35.3	0		R	M	M	CL	5Y4/1, dark gray	VS	N	H	N	VFS	S w/ HCl	Composite chemistry samples
36.0							5Y3/1 very dark gray							Gas voids
38.0														High dry strength
			S	M	M		5Y4/1, dark gray	S		SH		MS	N	YBM / OBM
40.0	5													
	10													
	15													

Core Data Log

Core #: C-32 *Logger:* Cadoret *Date:* 6/25/91

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
35.3	0		R	M	M	CL	5Y4/2 olive gray 5Y3/1 very dark gray	VS	N	H	N	Silt	S w/ HCl	Gas voids High dry strength Composite chemistry samples
36.0														
38.0			S	M	M	CH	5Y3/1 very dark gray 2.5Y5/4 light olive brown	S F		L H	S around $CaCO_3$ N elsewhere		N	YBM Laminae ≤2 mm, most < 1 mm OBM Carbonate stringers and small nodules Very high dry strength
40.0	5													
40.8														
	10													
	15													

Core Data Log

Core #: C-33 | Logger: Bjornstad | Date: 6/25/91 | Page 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
35.0	0		S	L	L	CL	5Y4/1, dark gray	VS	N	H	N	Silt	S w/ HCl	High dry strength
36.0							5Y3/1 very dark gray							
														High dry strength
38.0														Composite chemistry samples
														YBM
40.0	5			M	M	CH	5GY4/1 dark greenish gray	S					N	OBM
45.4								F						Very high dry strength
	10													
	15													

Core Data Log

Core #: C-35 *Logger:* Cadoret *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.2	0		R	M	M	CL	5Y4/1 dark gray	VS	N	H	N	VFS	S w/ HCl	Composite chemistry samples
38.0							5Y3/1 very dark gray					Silt		
40.0			S	M	M	CH	5GY4/1 dark greenish gray	F			S		N	YBM / OBM Carbonate nodules up to 1 cm in diameter
41.2	5													Very high dry strength
	10													
	15													

Core Data Log

Core #: C-36 *Logger:* Cadoret *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.1	0		R	L	M	CL	5Y4/1 dark gray ↓ 5Y3/1 very dark gray	VS	N	H	N	Silt	S w/ HCl	Very high dry strength; Composite chemistry samples
38.0			↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	YBM
40.0			S	M	M	CH	5GY4/1 dark greenish gray	F			S on $CaCO_3$ N elsewhere	VFS	N	OBM Carbonate nodules up to 0.5 cm in diameter; Very high dry strength
40.9	5													
	10													
	15													

Core Data Log

Core #: C-37 *Logger:* Bjornstad *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.1	0		S	M	M	CL	5Y4/2, olive gray 5Y2.5/1 black	VS	N	H	N	Silt	N	Composite chemistry samples
38.0								S						
		Fe Fe				CH	2.5Y4/2 dark grayish brown	F						YBM / OBM Very high dry strength
40.0						SM ML						FS Silt		Silty sand lens
41.0	5													Medium dry strength
	10													
	15													

Core Data Log

Core #: C-38 *Logger:* Bjornstad/Cadoret *Date:* 6/25/91 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
36.1	0		R	M	M	CL	5Y4/1 dark gray → 5Y2.5/1 black	VS	N	H	N	Silt	S w/ HCl	Composite chemistry samples
38.0		Fe	S	M	M	CL/CH CH → CL	5Y4/2 olive gray 5GY4/1 dark greenish gray	F	N	M H	S on $CaCo_3$ W to N elsewhere	VFS	N	YBM Mottled OBM & YBM OBM Iron oxide-filled root traces, Carbonate nodules up to 0.3 cm in diameter
40.0														
41.0	5													Very high dry strength
	10													
	15													

Core Data Log

Project: Heckathorn

Core #: IH-35 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.6	0		NA	NA	NA	CL	2.5YN3/ v. dark gray → 5Y4/1 dk. gray	VS	N	H	N	FS	N	A	
-36.6	1													X	
-38.0	2.4		NA	M	M	CL	5Y4/1 dk. gray	F–H	N	H	N	Z	N	Y	OBM
-39.0	3.4													Z	
-40.0	4.4														

Core Data Log

Project: Heckathorn
Core #: IH-36
Logger: PJ White
Date: 1-19-93
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Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.6	0		NA	NA	NA	CL	2.5Y4/2 grayish brown 2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	Top 0.5' lighter in color-oxidized
-36.6	1													B	shell fragments
-38.3	2.7													X	
-39.3	3.7		NA	M	M	CL	2.5Y3/2 v. dark grayish brown	F	N	H	N	Z	N	Y	several subrounded pebbles at contact ≤ 0.5"
-40.3	4.7						5Y4/1 dk. gray							Z	
-41.3	5.7														local $CaCO_3$ alt.
-43.8	8.2														photo

Core Data Log

Project: Heckathorn

Core #: IH-37 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.8	0		NA	NA	NA	CL	2.5Y4/2 grayish brown 2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	
-35.8	1													B	
-37.8	3											VFS		C	
-39.3	4.5													X	
-40.3	5.5		NA	M	M	CL	2.5Y4/4 olive brown	F	N	H	N	Z	N	Y	YBM in 0.2" crack in OBM
-41.3	6.5													Z	
-42.3	7.5			NA	NA	SC/CL						FS			
-44.4	9.6														
															2 photos

Core Data Log

Project: Heckathorn

Core #: IH-38 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.5	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS → VFS	faint S	A	
-37.5	1													X	
-38.7	2.2		NA	M	M	CL	5YN4/1 dk. gray	F	N	H	N	Z	N	Y	
-39.7	3.2													Z	
-40.7	4.2														
-41.2															

Core Data Log

Project: Heckathorn

Core #: IH-39 *Logger:* PJ White *Date:* 1-19-93

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.5	0		NA	NA	NA	CL	2.5Y4/2 dark grayish brown	VS	N	H	N	VFS	N	A	
-35.5	1						2.5YN3/ v. dark gray							B	
												FS			
-37.5	3						2.5YN2/ black					VFS		C	clast of OBM
-39.0	4.5													X	
-40.0	5.5		NA	M	M	CL	2.5Y4/2 dark grayish brown	F - H	N	H	N except $CaCO_3$ alt.	VFS - Z	N	Y	very hard!
-41.0	6.5													Z	patches of $CaCO_3$ alt.
-42.0	7.5														
-42.7	8.2														

UHRI DRAFT

Core Data Log

Project: Heckathorn

Core #: IH-40 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.5	0	λ	NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	roots
-36.5	1		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	B	
-38.0	2.5		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	X	
-39.0	3.5		NA	M	M	CL	5Y4/1 dk. gray	H	N	H	N	Z	N	Y	
-40.0	4.5		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	Z	
-41.0	5.5		↓	↓	↓	↓	↓	F	↓	↓	↓	FS	↓		
-43.9	8.4		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		

Core Data Log

Project: Heckathorn

Core #: IH-41 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.4	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	grayish brown at surface
-36.4	1													B	
-38.4	3									M-H				C	black areas
-39.4	4													X	
-40.4	5		NA	M	M	CL	5Y4/1 dk. gray	H	N	H	N except alt.	Z	N	Y	
-41.4	6													Z	
-42.4	7														$CaCO_3$ alt. in patches
-44.1	8.7														

Core Data Log

Project: Heckathorn

Core #: IH-42 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-38.4	0		NA	NA	NA	CL	2.5Y4/2 dk grayish brown 2.5YN3/ v. dark gray	VS	N	H	N	VFS	faint S	A	0.4' of grayish brown mud over dark gray - sharp contact - recent deposition
-39.4	1													X	
-40.0	1.6		NA	M	M	CL	5Y4/1 dk. gray	H	N	H	N	Z	N	Y	OBM
-41.0	2.6													Z	
-42.0	3.6											VFS			
-43.3	4.9														

Core Data Log

Project: Heckathorn
Core #: IH-43 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.1	0		M	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	
-36.1	1													B	
-38.1	3													X	
-39.1	4		NA	M	M	CL	5Y4/1 dk. gray	HI	N	H	N	Z	N	Y	
-40.1	5													Z	
-41.1	6														
-43.9	8.8														photo

Core Data Log

Project: Heckathorn

Core #: IH-44 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.6	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS	faint S	A	grayish brown on top
-35.6	1													B	
-37.6	3						2.5YN2/ black								gas holes
														C	
-39.6	5													D	
-41.6	7													X	
-42.6	8		NA	M	M	CL	2.5Y4/2 dark grayish brown	F – H	N	H	N	Z	N	Y	upper 2" disrupted
-43.6	9													Z	
-44.6	10														
-46.4	11.8														

UHRI DRAFT

Core Data Log

Project: Heckathorn

Core #: IH-45 *Logger:* PJ White *Date:* 1-20-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.8	0		NA	NA	NA	CL	5Y4/1 dk. gray	VS	N	H	N	VFS	N	A	
-35.8	1						2.5YN3/ v. dark gray							B	contact between lighter gray muck and darker clay gas holes
-37.8	3													C	
-39.1	4.3													X	
-40.1	5.3		NA	M	M	CL	5Y4/1 dk. gray	F	N	H	N	Z	N	Y	0.2' brownish alt. in OBM below contact
-41.1	6.3													Z	
-42.1	7.3														
-43.1	8.3														

Core Data Log

Project: Heckathorn

Core #: IH-46 *Logger:* PJ White *Date:* 1-20-93 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.8	0		NA	NA	NA	CL	5Y4/1 dk. gray	VS	N	H	N	VFS	N	A	
-35.8	1														
														B	
-37.8	3						2.5YN3/ v. dark gray								contact between gray muck and dark gray YBM
														C	gas holes
-39.8	5														
	6													X	
-40.8			NA	M	M	CL	2.5Y4/4 olive brown	H	N	H	N	Z	N		very sharp contact
-41.8	7													Y	
-42.5	7.7													Z	
															photo

Core Data Log

Project: Heckathorn

Core #: IH-47 *Logger:* PJ White *Date:* 1-20-93 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.7	0		NA	NA	NA	CL	5Y4/1 dk. gray	VS	N	H	N	VFS	N	A	
-37.7	1													B	gas holes
							2.5YN3/ v. dark gray								
-39.7	3													C	
-40.5	3.8						2.5YN2/ black							X	drier (dull appearance)
-41.5	4.8		NA	NA	NA	CL	5GY5/1 greenish gray	F	N	H	N	few pebbles ≤0.2"	N	Y	
-42.5	5.8					SC/CL						pebbles ≤0.5"		Z	
-43.5	6.8														

Core Data Log

Project: Heckathorn

Core #: IH-48 *Logger:* PJ White *Date:* 1-20-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.1	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS	N	A	
-36.1	1													B	gas holes
-38.5	3.4													X	
-39.5	4.4		NA	M	M	CL	2.5Y4/4 olive brown	H	N	H	N	Z	N	Y	YBM intruded in crack
-40.5	5.4													Z	
-40.9															

Core Data Log

Project: Heckathorn

Core #: IH-49   *Logger:* PJ White   *Date:* 1-20-93   *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.4	0		NA	NA	NA	CL	5Y4/1 dk. gray	VS	N	S, black layers	N	VFS	N	A	0.2' black sed
-36.4	1						2.5YN3/ v. dark gray			H		FS		B	
-38.1	2.7													X	gas holes
-39.1	3.7		NA	NA	NA	CL	2.5Y4/4 olive brown	F	N	H	N	Z	N	Y	
-39.9	4.5														
															No Z sample

Core Data Log

Project: Heckathorn

Core #: IH-50 *Logger:* PJ White *Date:* 1-14-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)
-35.9	0
-36.9	1
-38.9	3
-39.7	3.8
-40.7	4.8
-41.2	5.3
-42.2	6.3
-43.2	7.3
-45.5	9.6
-50.0	14.1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.9 to -40.7	0 to 4.8		NA	NA	NA	CL	2.5Y4/4 olive brown → 2.5YN3/ v. dark gray	VS	N	H	N	Z	N	A, B, C, X	YBM; gas holes; not sampled-disrupted by core caps; sharp contact
-40.7 to -45.5	4.8 to 9.6					SC; GW/GC	5Y4/2 ol gr; 5Y5/4 olive; 2.5Y4/4 olive brown	F; S	N		N	FS; VCS pebbles to 1" → VFS; pebbles		Y, Z	OBM → sand-silt-clay-gravel mixture
-45.5 to -50.0	9.6 to 14.1														(did not look at this section in detail)

Core Data Log

Project: Heckathorn

Core #: IH-51 | Logger: PJ White | Date: 1-14-93 | Page 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.3	0		NA	NA	NA	CL/CH	2.5Y4/4 olive brown	VS	N	H	N	Z	N	A	YBM
-36.3	1						2.5YN3/ v. dark gray							B	
-37.3	2													X	
	3						2.5YN2/ black								
-38.3						CL/CH	2.5Y4/4 olive brown	F to S	N	H	N	Z	N		altered zone- grayish OBM
-38.5	3.2													Y	
	3.9					CL/CH									
-39.5	4.2													Z	
-40.5	5.2											FS			
						SC				see holes		MS			Sand shows flow structures- concentric and longitudinal layering
-43.6	8.3														
															2 photos

UHRI DRAFT

Core Data Log

Project: Heckathorn

Core #: PC-52 *Logger:* PJ White *Date:* 1-20-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-3.8	0	λ	NA	NA	NA	CL	2.5YN2/ black	VS	N	H	N	FS	strong S	A	Many roots and chunks of wood
-4.8	1	λ											strong P	B	gas holes; oily appearance
-6.8	3	λ												C	
-7.9	4.1														
															photo

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: SF-1 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-38.5	0		R	M	M	CL	5Y3/1 v dk gray	VS	N	H	N	FS	N	Sed Chem	YBM
			NA	NA	NA	ML	5Y4/1 dk gray	H	N	H	N	VFS	N		OBM
40	1.5													Sed Chem	Patches of white alteration - calcite
-42	3.5														

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: SF-2 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-37.8	0		R	M	M	CL	5Y3/1 v dark gray / 2.5YN2/ black	VS / S	N	H	N	FS / VFS	N	Sed Chem	change in consistency & odor - old dredging surface?
-40	2.2														YBM / OBM
-40.9	3.1		NA	NA	NA	ML	5Y4/1 dk gray	F	N	H	N	FS pebbles	N	OBM	rounded pebbles <0.2 in.
-42	4.2														

B.22

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: SF-4 *Logger:* PJ White *Date:* 2-10-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.9	0		R	M	M	CL	5Y3/1 v dark gray → 2.5YN2/ black → 5Y3/1 v dark gray	VS → S	N	H	N	FS → VFS → FS-VFS	N → P-N	Sed Chem	wood fiber worm
-40	4.1														YBM
-41	5.1		NA	NA	NA	SC → ML	5Y3/1 v dark gray	F	N	H	N	MS → Z	N	OBM	OBM
-42	6.1														

B.24

DRAFT RH-DEEPENING

Core Data Log

Project: Heckathorn

Core #: SF-27 | *Logger:* PJ White | *Date:* 1-18-93 | *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.3	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	
-36.3	1													B	
-38.3	3													C	
-39.3	4						+ 5Y4/1 dk. gray			M				X	very dark gray CL with FS and dark gray CL with Z
-40.3	5		NA	M	M	CL	5Y4/1 dk. gray	H	N	H	N, except $CaCO_3$ alt.	Z – FS	N	Y	OBM
-41.3	6													Z	locally altered $CaCO_3$
-41.8	6.5														

Core Data Log

Project: Heckathorn
Core #: SF-28 *Logger:* PJ White *Date:* 1-18-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.6	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	faint S	A	
-36.6	1		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	B	
			↓	↓	↓	↓	2.5YN2/ black	S	↓	↓	↓	Z	N		
-38.3	2.7		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	X	dark gray OBM CL clast
-39.3	3.7		NA	NA	NA	SP	5Y4/2 olive gray	F	N	H	N	CS ↓ few pebbles	N	Y	OBM
-39.8	4.2														
															photo

UHRI DRAFT

Core Data Log

Project: Heckathorn

Core #: SF-29 *Logger:* PJ White *Date:* 1-18-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-27.1	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	
-28.1	1	λ												B	sparse roots
		λ													root
-30.1	3							S						C	
															shell
-32.1	5						2.5YN2/ black							D	clast of OBM-dark gray SC
												Z			
-34.1	7									M, faint S		FS		E	
												Z			
-35.9	8.8					SC/CL						pebbles ≥0.5'		X	
-36.9	9.8		NA	M	M	CL	5Y4/1 dk. gray	H	N	H	N except $CaCO_3$ alt.	Z	N	Y	OBM
-37.9	10.8													Z	local CaCO3 alt.
-38.9	11.8														white, powdery
-39.7	12.6														

Core Data Log

Project: Heckathorn

Core #: SF-30 *Logger:* PJ White *Date:* 1-18-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.1	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS → FS		A	
-37.1	1													B	
-37.9	1.8													X	
-38.9	2.8		NA	M	M	CL	5Y4/1 v. dark gray	F – H	N	H	N	Z		Y	→ change in consistency from F to very H
-39.9	3.8													Z	
-40.8	4.7														

Core Data Log

Project: Heckathorn

Core #: SF-31 | *Logger:* PJ White | *Date:* 1-18-93 | *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.9	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS	N	A	
-37.9	1											Z		X	
	2														
-38.9			NA	M	M	CL	5Y4/1 dk. gray	F - H	N	H	N	Z	N	Y	distinct change in texture from F to very H
-39.9	3													Z	$CaCO_3$ alt.
-40.9	4														

Core Data Log

Project: Heckathorn

Core #: SF-32 *Logger:* PJ White *Date:* 1-16-93 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-27.5	0		NA	NA	NA	CL	2.5YN3/ dk. gray	VS	N	H	N	VFS	faint S	A	
-28.5	1													B	clam shell fragments
													rubbery smell		many roots
-30.5	3											FS	N	C	
-32.2	4.7											Z		X	
-33.2	5.7		NA	M	M	CL	5Y5/2 olive gray 5Y4/1 dk. gray	H	N	H	N, except alt.	Z	N	Y	~3" band OBM of olive gray clay over gray clay
-34.2	6.7													Z	
-35.2	7.7														$CaCO_3$ alteration - sparse, white powder surfaces
-35.8	8.3														

UHRI DRAFT

Core Data Log

Project: Heckathorn

Core #: SF-33 *Logger:* PJ White *Date:* 1-16-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.9	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS	faint S	A	
-36.9	1														
													N	B	gas holes
-39.1	3.2													X	
	4.2														
-40.1			NA	NA	NA	SC	5Y4/1 dk. gray	F	N	H/S	N	MS	N	Y	OBM
-41.1	5.2		NA	M	M	CL		H				Z		Z	
-42.1	6.2														
-42.8	6.9														

UHRI DRAFT

Core Data Log

Project: Heckathorn

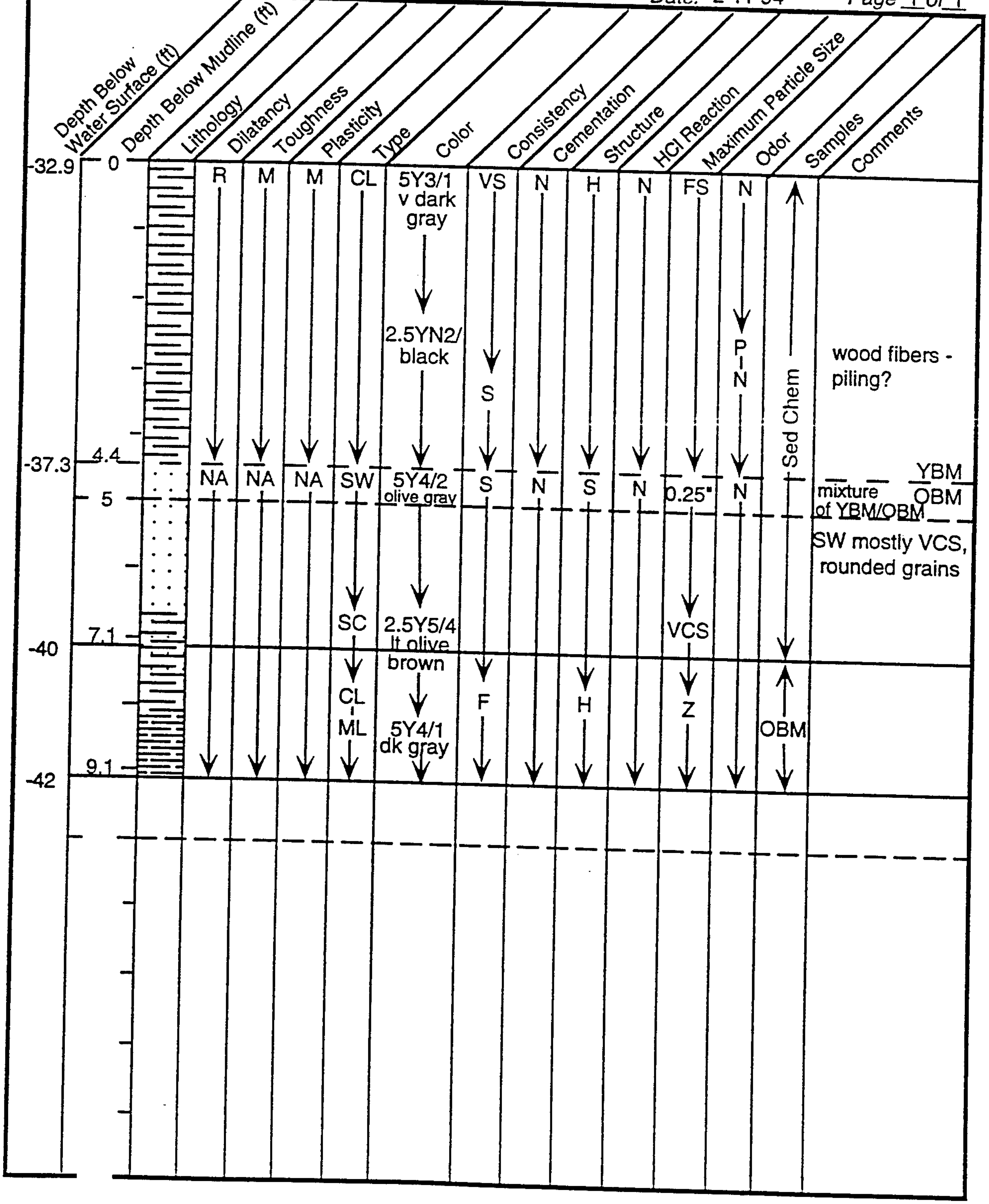
Core #: SF-34 *Logger:* PJ White *Date:* 1-16-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-38.0	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS	faint S	A	
-39.0	1													B	
-39.8	1.8							VS/S						X	mixture of YBM & OBM - disrupted zone
-40.8	2.8		NA	M	M	CL	5Y4/1 dk. gray	F	N	H	N	Z	N	Y	OBM
-41.8	3.8													Z	
-42.2	4.2														

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: SFW-1 *Logger:* PJ White *Date:* 2-11-94 *Page* 1 *of* 1



Core Data Log

Project: Port of Richmond Maintenance and Deepening Project

Core #: SFW-2 *Logger:* PJ White *Date:* 2-11-94 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.1	0		NA	NA	NA	CL	5Y3/1 v dark gray 2.5YN2/ black	VS	N	H	NA	FS	N	Archive-Maintenance	mussel shell, oily appearance
-37	2.9														mussel shell
							5Y4/1 dk gray								
-39.3	5.2		NA	NA	NA	ML	5Y4/1 dk gray	H	N	H	NA	Z	N		YBM
-40	5.9														OBM
															patches of whitish alteration - calcite
-42	7.9														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Project

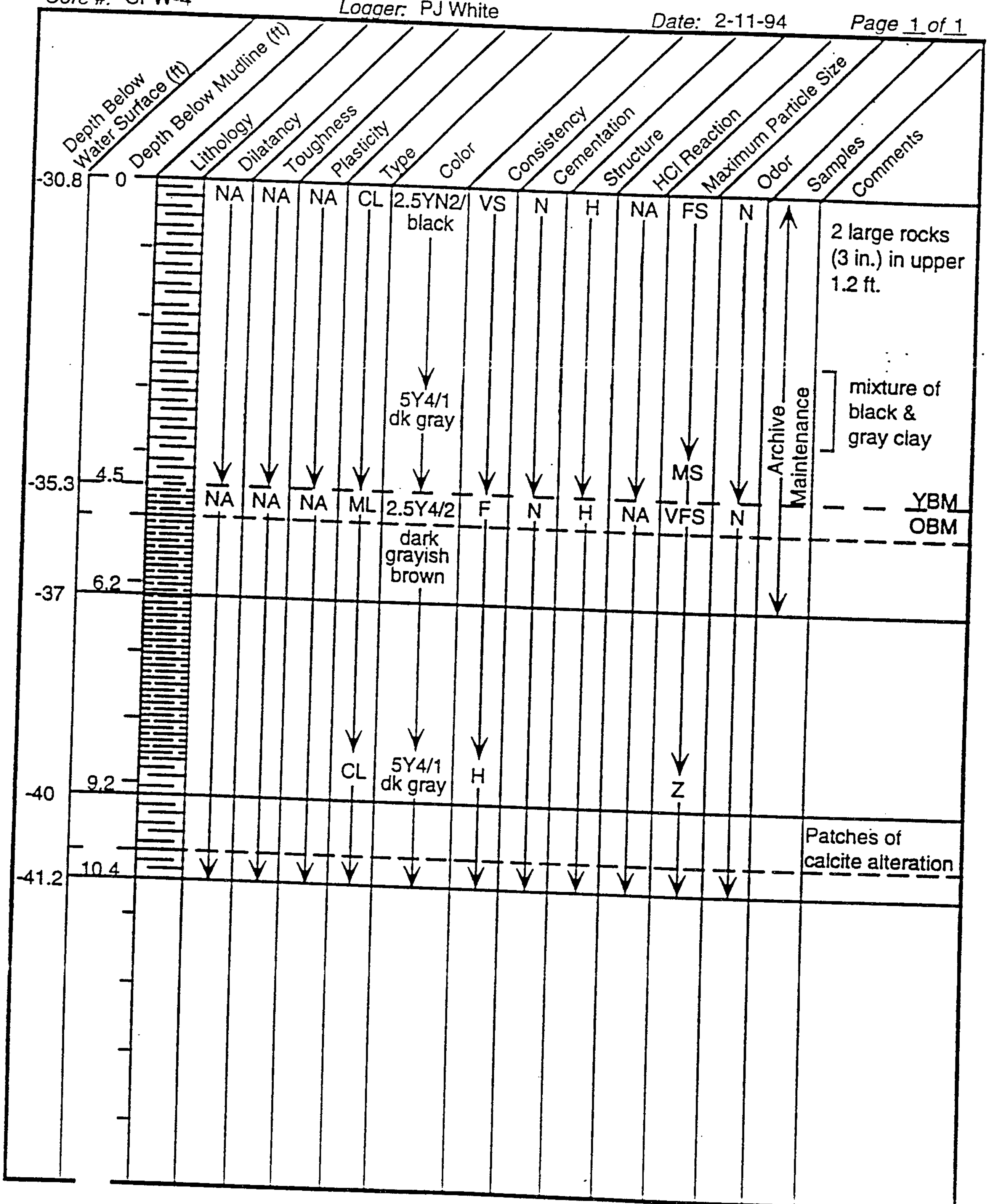
Core #: SFW-3 *Logger:* PJ White *Date:* 2-11-94 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-28.0	0		NA	NA	NA	CL	5Y3/1 v dark gray → 2.5YN2/ black → 5Y4/1 dk gray → (0.1 ft black)	VS → S?	N	H	NA	FS → Z → FS	N → P N → naph-thalene → N	Archive Maintenance	grades from black to gray clay; naphthalene smell
-35.2	7.2		NA	NA	NA	ML	5Y4/1 dk gray 2.5Y4/2 dark grayish brown	F	N	H	NA	VFS	N		YBM / OBM
-37	9					CL → ML	5Y4/2 olive gray	H				Z → FS			
-40	12														
-40.5	12.5														

Core Data Log

Project: Port of Richmond Maintenance and Deepening Project

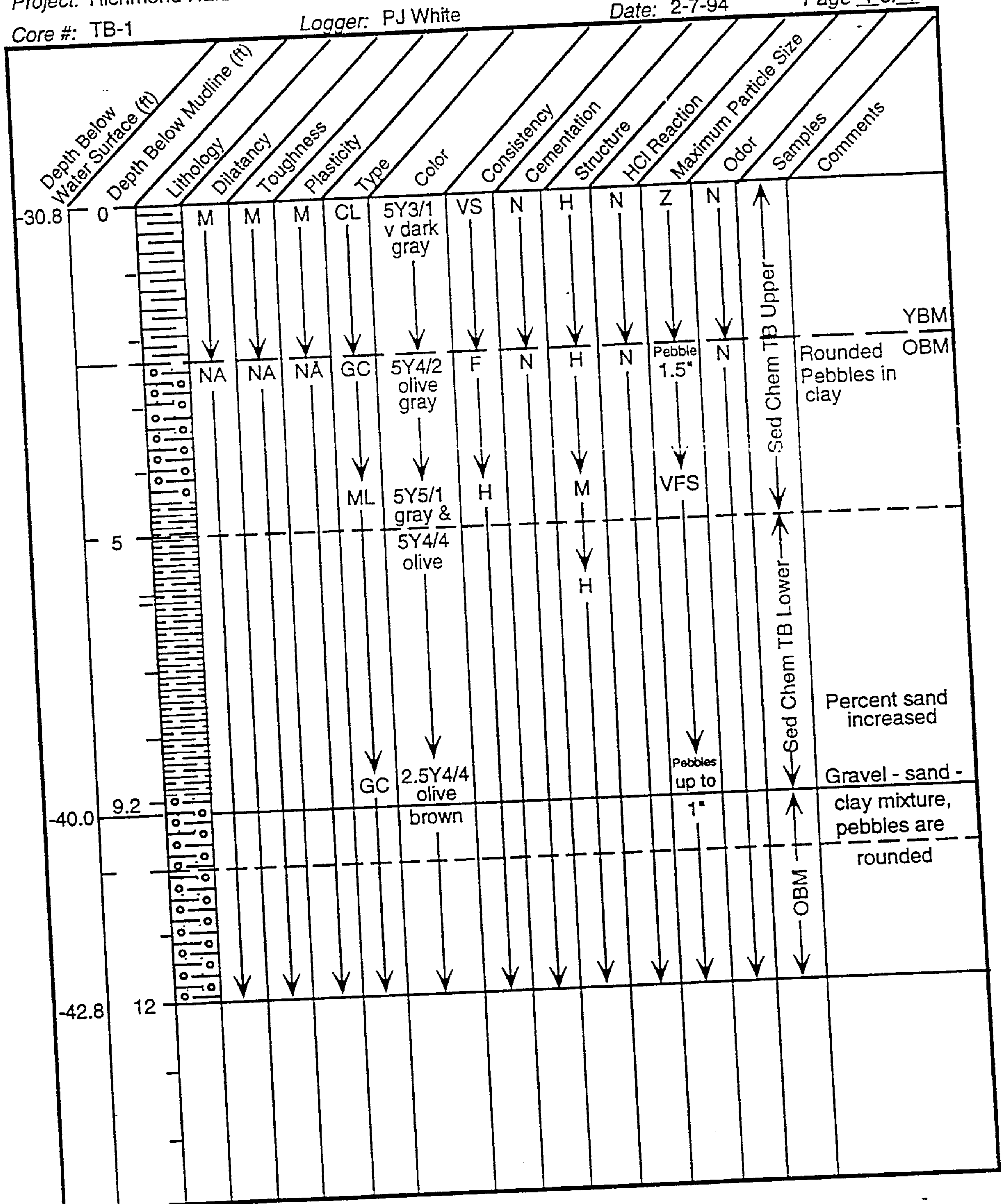
Core #: SFW-4 *Logger:* PJ White *Date:* 2-11-94 *Page* 1 *of* 1



Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-1 *Logger:* PJ White *Date:* 2-7-94 *Page* 1 *of* 1



Core Data Log

Project: Richmond Harbor Intensive Study | *Page* 1 *of* 3

Core #: TB-2 | *Logger:* PJ White | *Date:* 2-8-94

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-5.2	0		M/R	M	M	CL	5Y4/1 dk gray	VS	N	H	N	FS	N	Sed Chem TB Upper	Shell fragments in clay
												Z			
			NA	NA	NA						reacts with shell frags		S		Shell hash from 3.5-5.5 Some whole clam shells, abundant shell fragments
	5		M	M	M			S			N				
															few shell frags & pieces of organic matter
															whole clam shell
	10													Sed Chem TB Lower	few shell fragments & gas holes
															whole clam shell

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-2 *Logger:* PJ White *Date:* 2-8-94 *Page* 2 of 3

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
15			M	M	M	CL	5Y4/1 dk gray	S	N	H	N	Z	N	Sed Chem TB Lower	Few shell fragments & gas holes
								F-S-F							
20								S							
25															
			NA	NA	NA	SC		F				MS			
								S				Pebbles			Pebbles rounded up to 0.5"
												VCS			

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-2 *Logger:* PJ White *Date:* 2-8-94 *Page* 3 *of* 3

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	30 – 34.8		NA → M	NA → M	NA → M	SC → CL	5Y4/1 dk gray	S	N	H	N	VCS – CS – Z	N	Sed Chem TB Lower	Sand grains SA to SR, mostly quartz; gas holes
-40															

B.4

DRAFT RH-DEEPENING

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-3 *Logger:* PJ White *Date:* 2-8-94 *Page* 1 *of* 3

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-4.6	0		M	M	M	CL	5Y4/1 dk gray	VS	N	H	N	FS	N	Sed Chem TB Upper	Few shell fragments
												Z			
											reacts with shell frags				Abundant shell, fragments 4" - 6"
	5										N		S	Sed Chem TB Lower	
								S							
															clam shell fragments
	10														

Core Data Log

Project: Richmond Harbor Intensive Study *Date:* 2-8-94 *Page* 2 of 3

Core #: TB-3 *Logger:* PJ White

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	15		M	M	M	CL	5Y4/1 dk gray	S	N	H	N	Z	S	Sed Chem TB Lower	shell fragments, few gas holes
	20														few shell fragments & gas holes
													N		
															irregularly-shaped concretion
	25														
												MS			
			NA	NA	NA	SC									
												pebble			Pebbles rounded, up to 0.5"
			M	M	M	CL						Z			

Core Data Log

Project: Richmond Harbor Intensive Study **Date:** 2-8-94 **Page** 1 of 1

Core #: TB-4 **Logger:** PJ White

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	0		M	M	M	CL	5Y3/1 v dark gray	VS	N	H/M	N	Z	N	Sed Chem TB Upper	gas holes
							5Y3/1 v dark gray & 2.5YN2/ black (mixed)								alternating areas of black and dark gray mud
	5						2.5YN2/ black			H				Sed Chem TB Lower	
															clast of dark gray mud in black mud
	10						5Y4/1 dk gray	S							
-40	11.7														
	15														

DRAFT RH-DEEPENING

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-5 *Logger:* PJ White *Date:* 2-8-94 *Page* 1 *of* 3

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-6.3	0		M	M	M	CL	5Y4/1 dk gray	VS	N	H	N	FS – Z	N → S	Sed Chem TB Upper	clam shell fragments
	5													Sed Chem TB Lower	
								S							
								VS – S							
	10														fewer shell frags
															gas holes
															whole clam shell

DRAFT RH-DEEPENING

Core Data Log

Project: Richmond Harbor Intensive Study
Date: 2-8-94
Page 2 of 3
Core #: TB-5
Logger: PJ White

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	15		M	M	M	CL	5Y4/1 dk gray	S	N	H	N	Z	N	Sed Chem TB Lower	Few shell fragments, few gas holes
	20														very few shell fragments
															whole clam (Macoma) filled with hard material
	25												MS		
			NA	NA	NA	SC							CS		
			M	M	M	CL							Z		roots
															clay

DRAFT RH-DEEPENING

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-5 *Logger:* PJ White *Date:* 2-8-94

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	30		M	M	M	CL	5Y4/1 dk gray	S	N	H	N	Z	N	Sed Chem TB Lower	roots in clay
															few roots
-40	33.7														
	35														
-41.8															

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-6 *Logger:* PJ White *Date:* 2-8-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	0	λ	M	M	M	CL	5Y4/1 dk gray	S	N	H	N	Z	N	Sed Chem TB Upper	organic matter (roots?) in upper 3' - brown, thin, vertical orientation; few gas holes
	5													Sed Chem TB Lower	
-40	9.1														
															Did not log third section (10-15'). Same lithology as 5-10'

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-7 **Logger:** PJ White **Date:** 2-9-94 Page 1 of 3

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	0		M	M	M	CL	5Y4/1 dk gray	VS	N	H	N	FS-Z	N strong S	Sed Chem TB Upper	clam shells in clay - *Macoma*?
	5													Sed Chem TB Lower	fewer shells; few gas holes; whole clam shell; whole clam shell
								S							
	10												S		gas holes, fewer shell fragments
													N		shell fragments

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: TB-7 *Logger:* PJ White *Date:* 2-9-94

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	15		M	M	M	CL	5Y4/1 dk gray	S	N	H	N	Z	N ↓ S N		few gas holes; shell fragment
	20	λ	NA ↓ M	NA ↓ M	NA ↓ M	SC-CL						MS ↓ Z		Sed Chem TB Lower	decayed organic matter - plant material
	25	λ													few gas holes; plant material

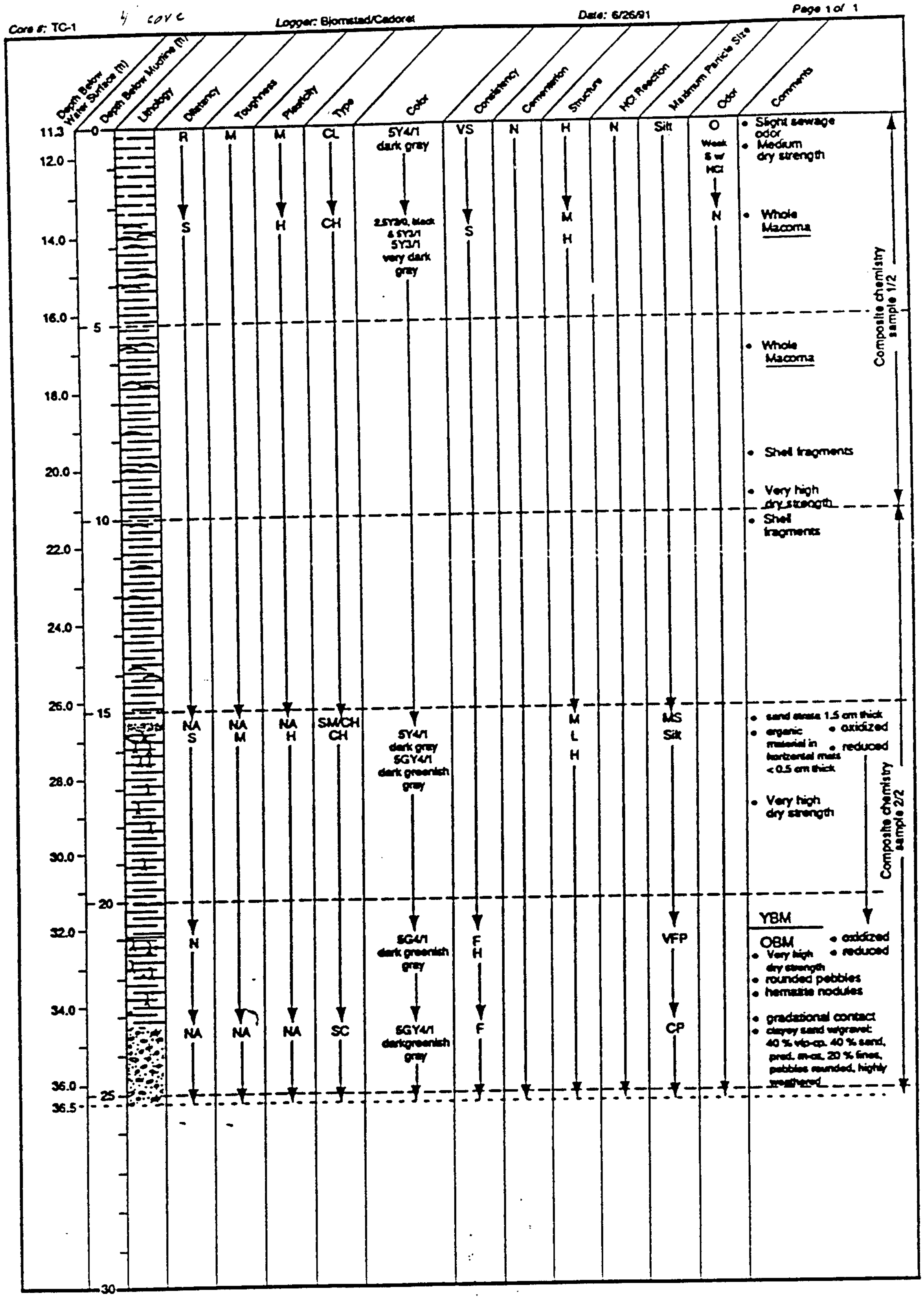
Core Data Log

Project: Richmond Harbor Intensive Study
Core #: TB-7
Logger: PJ White
Date: 2-9-94

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
	30 – 31.4		M	M	M	CL	5Y4/1 dk gray	S	N	H	N	Z	N	Sed Chem	few gas holes
-40															Did not log 31.4 - 35 ft. Similar lithology from 31.4 - 34'.
															34 - 35': Sediment is slightly siltier & browner (last 0.2 ft has bluish cast) - also contains more plant material - brown, vertical roots?

Core Data Log

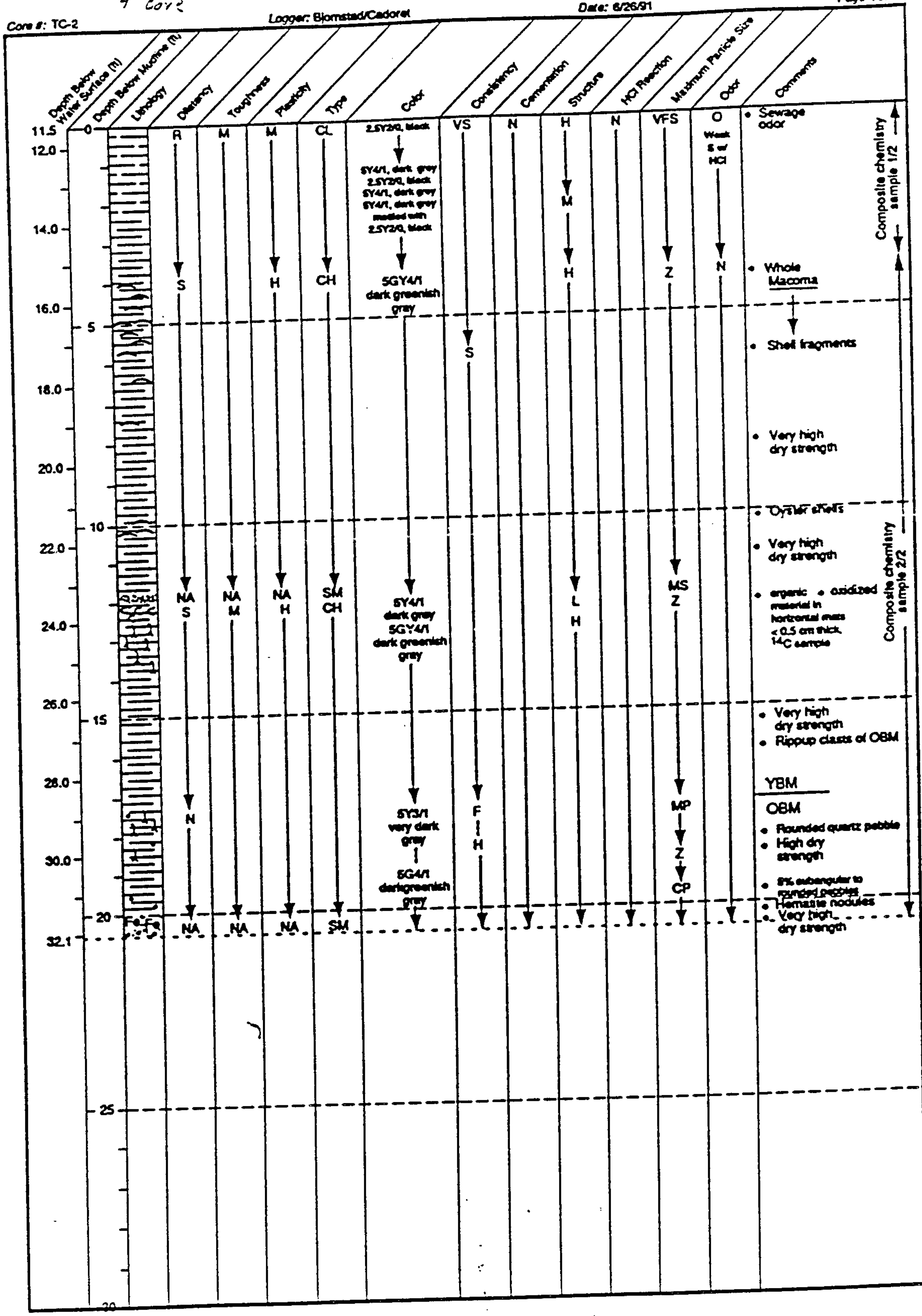
Core #: TC-1 ½ core   Logger: Bjornstad/Cadoret   Date: 6/26/91   Page 1 of 1



4" Core

Core Data Log

Core #: TC-2 Logger: Blomstad/Cadoret Date: 6/26/91 Page 1 of 1



12' core

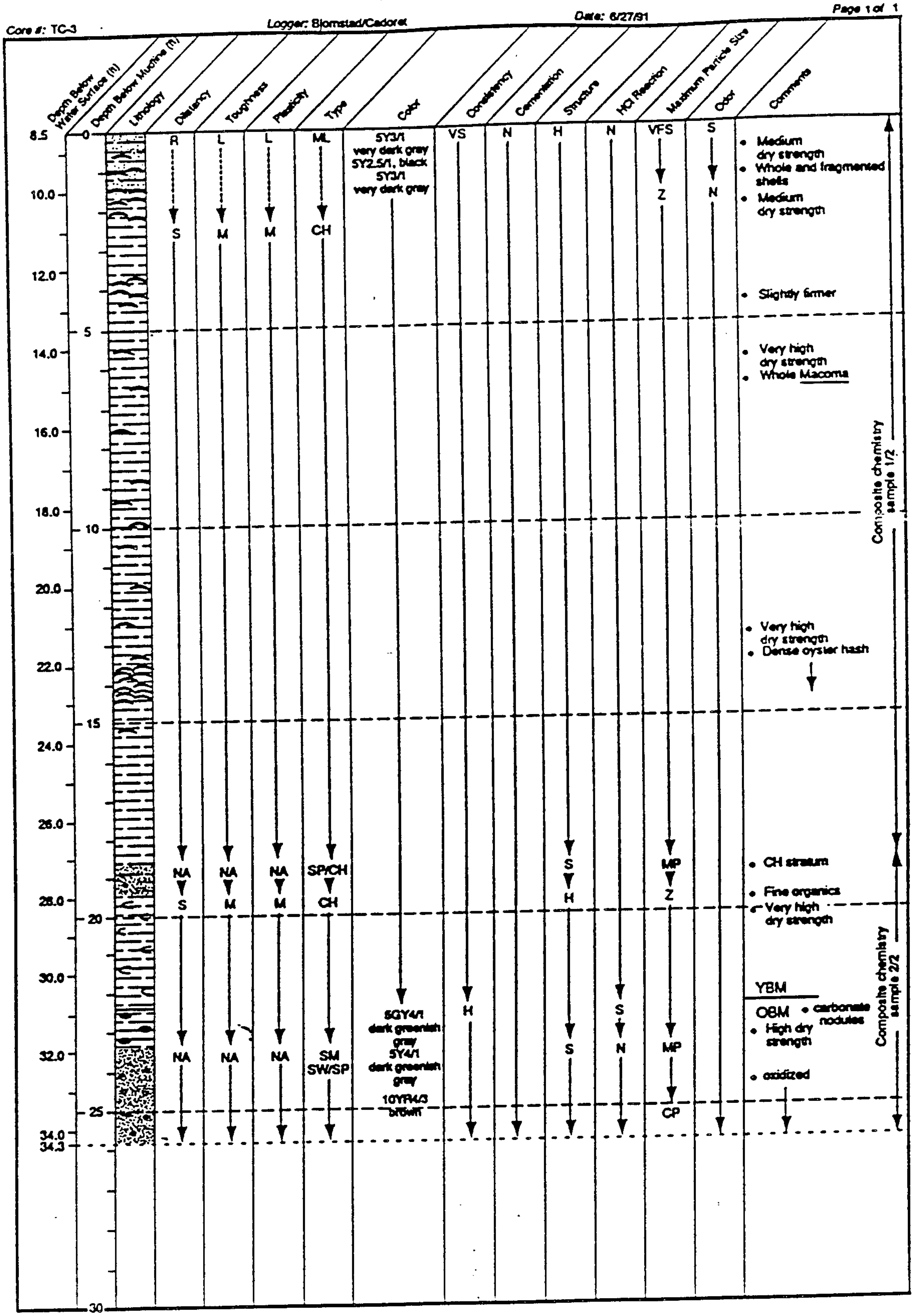
Core Data Log

Core #: TC-2, 12 inch core | Logger: Cadoret | Date: 6/20/91 | Page 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
11.5	0													• Soft, black, oily silt, stratified with grayish green silt. Strong odor of hydrogen sulfide.
12.0														
14.0														• Sticky, slightly firm, greenish gray, silty clay with small shells.
16.0	5													
18.0														
20.0														
22.0	10													
24.0														
26.0	15													
28.0														• Firm, silty clay with small shells.
30.0														• Silty clay with many roots.
32.0	20													• Firm grayish green, silty clay.
34.0														
36.0	25													
38.0														• Soft, sticky, greenish gray, silty clay.
40.0														
42.0	30													YBM / OBM • Very firm, dark grayish green, silty clay with granules-MP. Pebblesare rounded.
44.0														
46.0	35													
48.0														• Stratified, greenish gray, sandy gravel. Subangular to rounded gravels.
49.5														

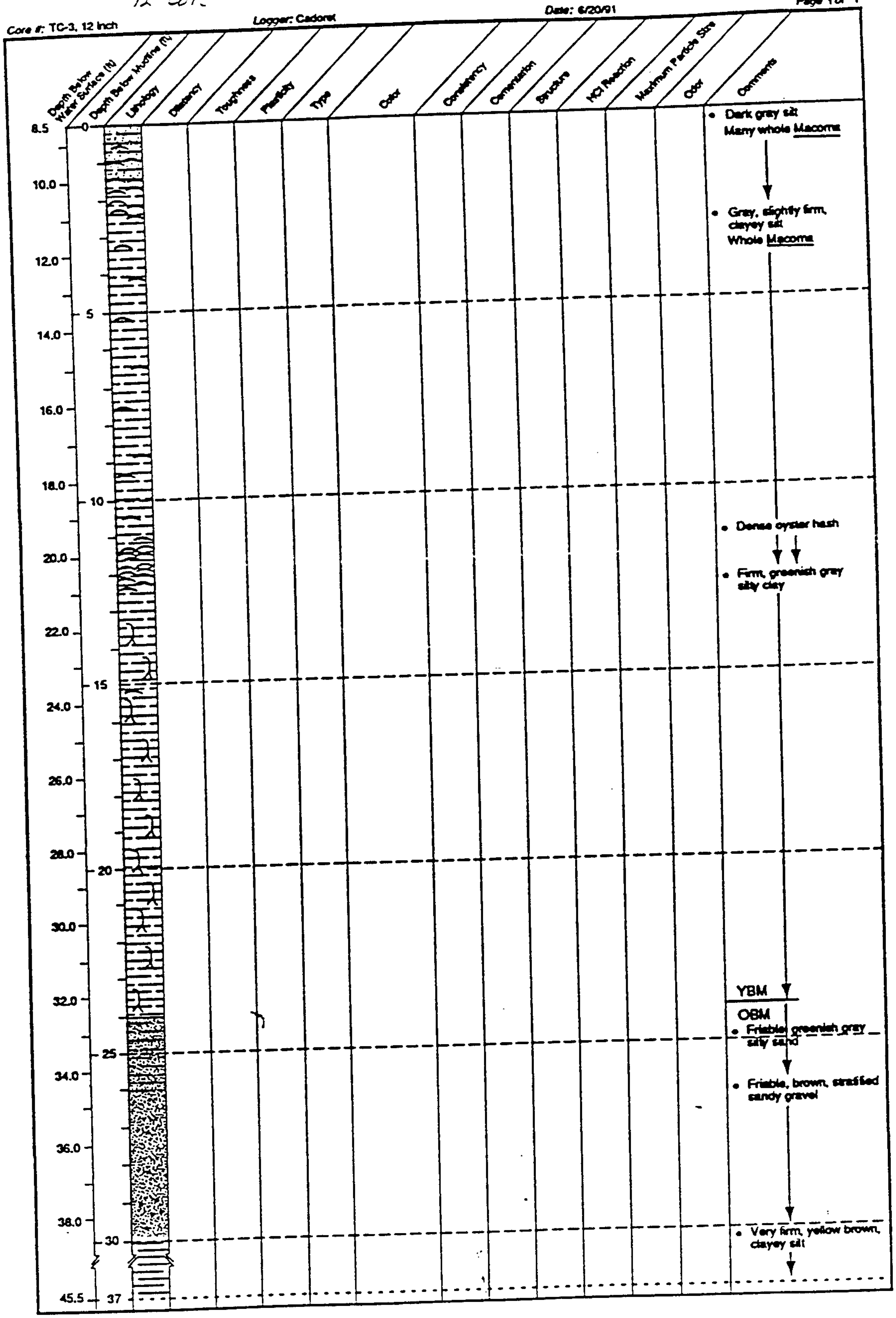
4" core

Core Data Log



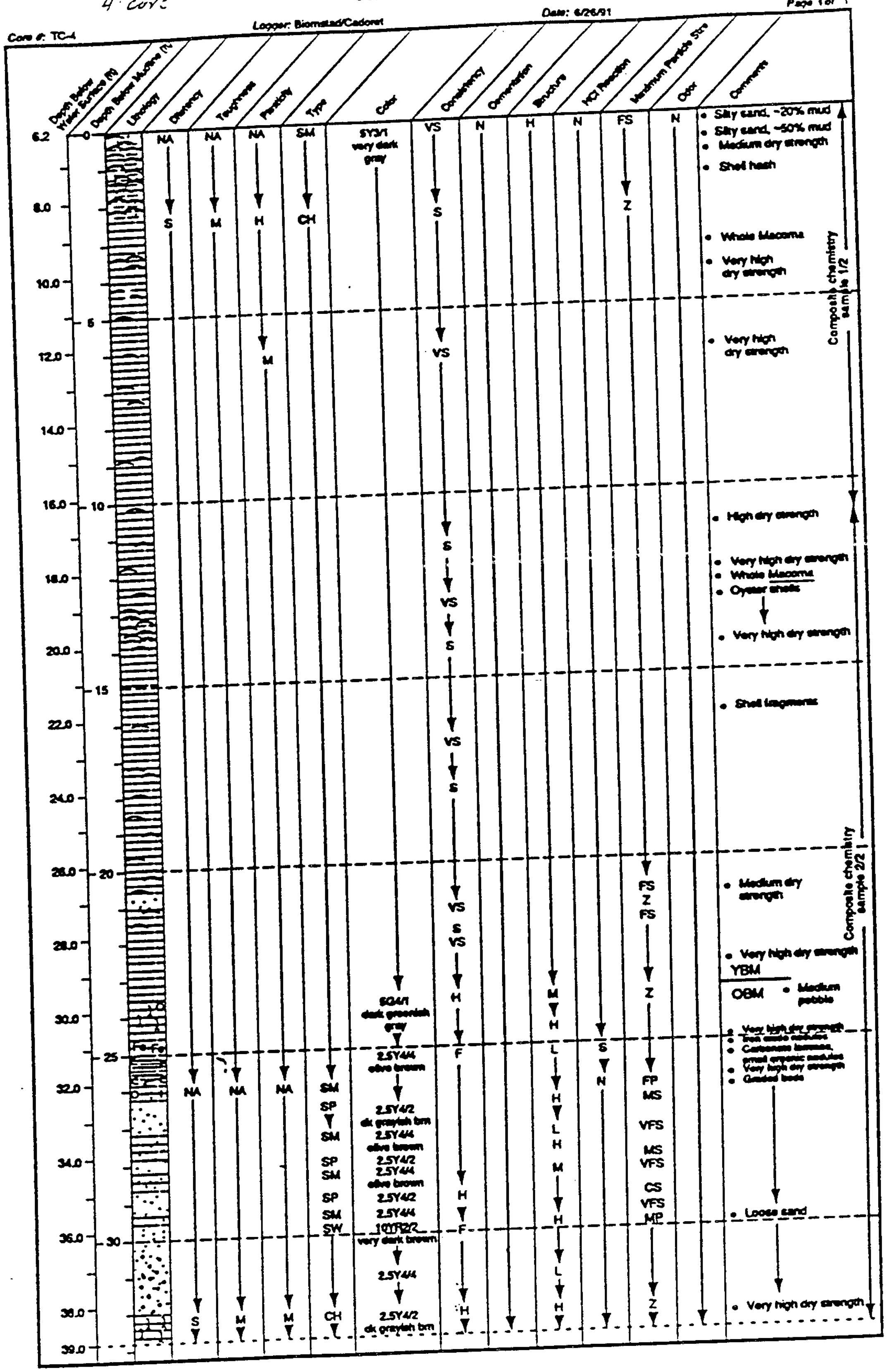
12" core

Core Data Log



4" core

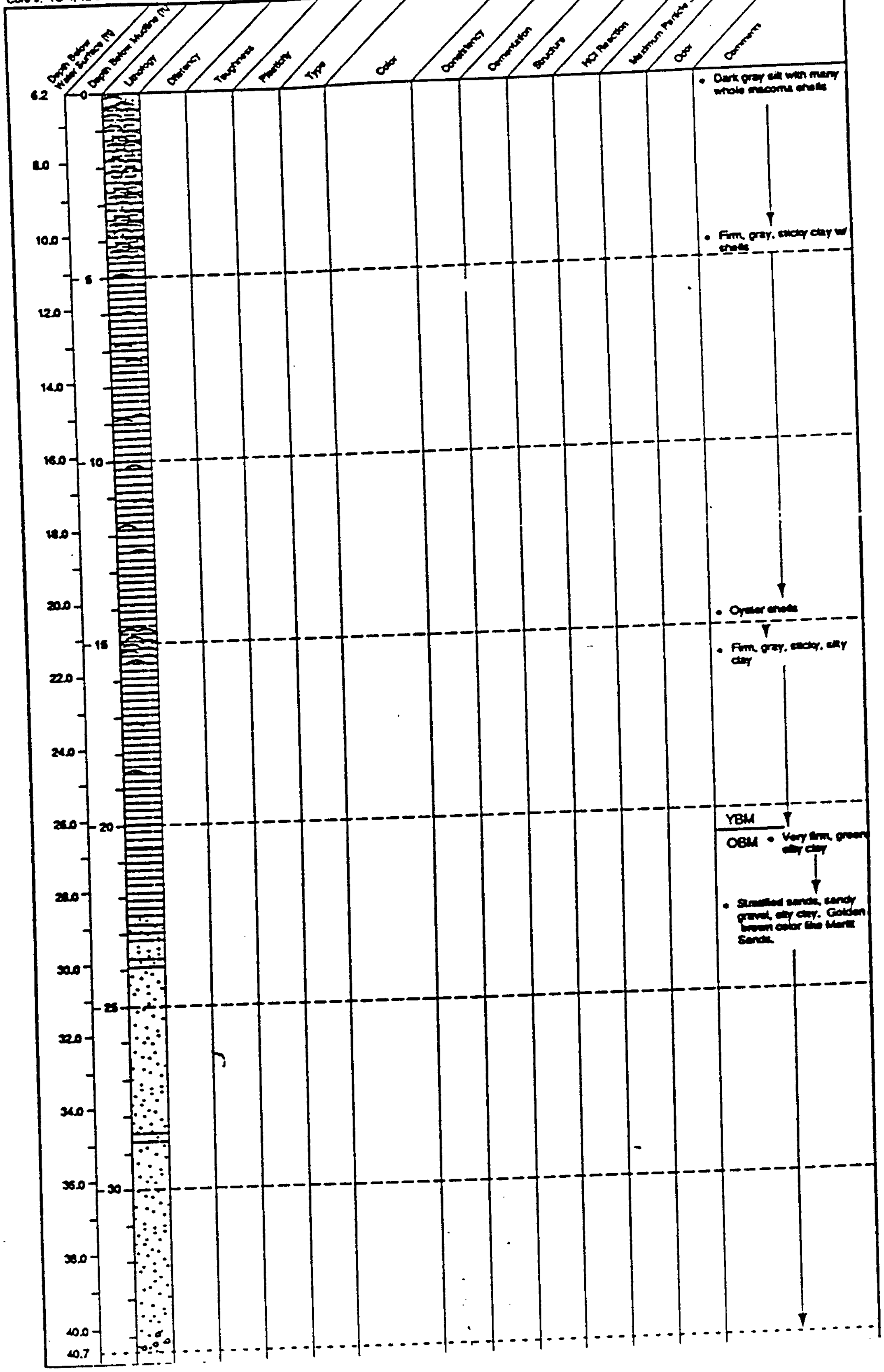
Core Data Log



12" core

Core Data Log

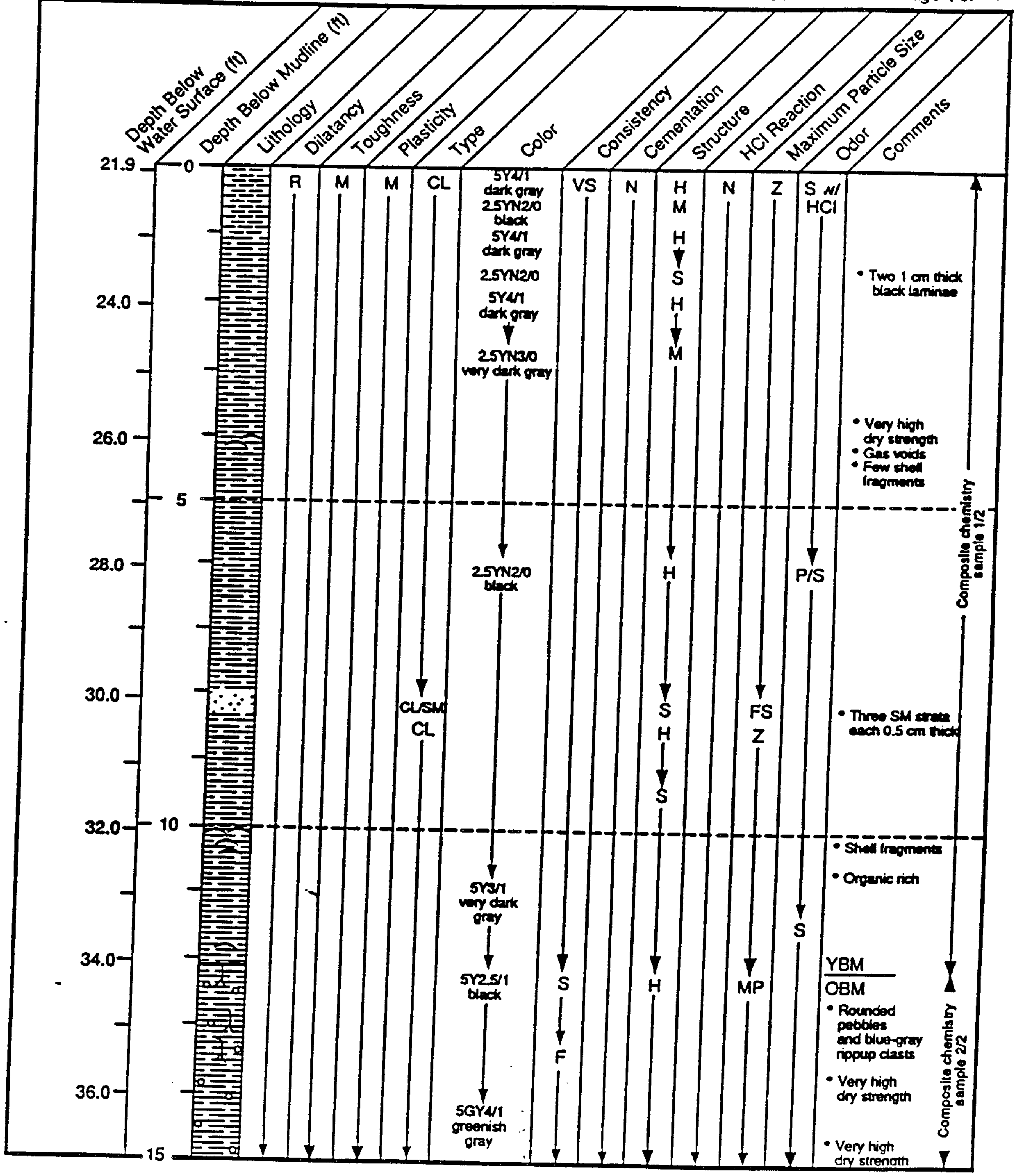
Core #: TC-4, 12 inch core | Logger: Cadoret | Date: 6/20/91 | Page 1 of 1



Core Data Log

4" core

Core #: TC-5 *Logger:* Bjornstad/Cadoret *Date:* 6/25/91 *Page* 1 *of* 1



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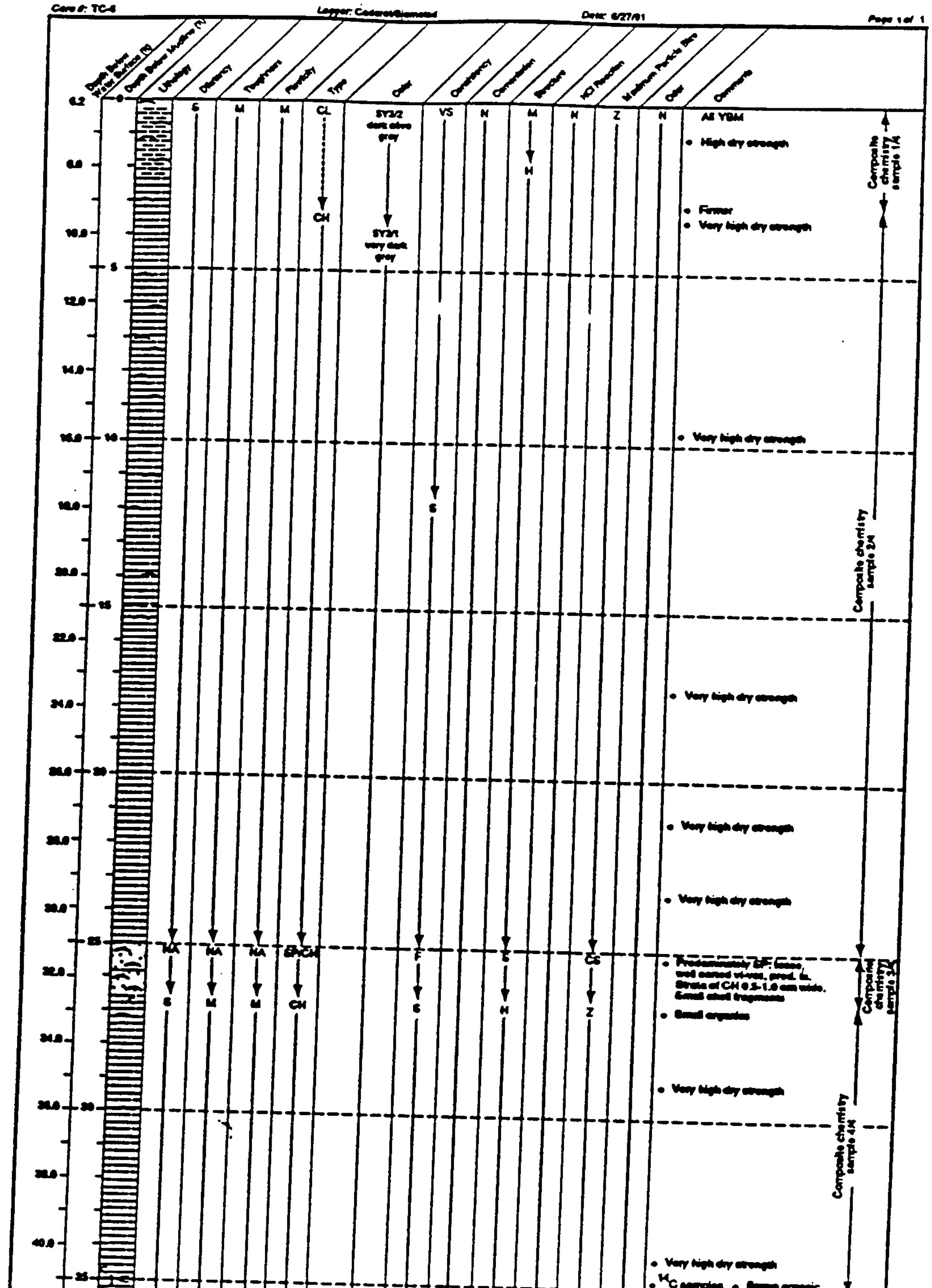
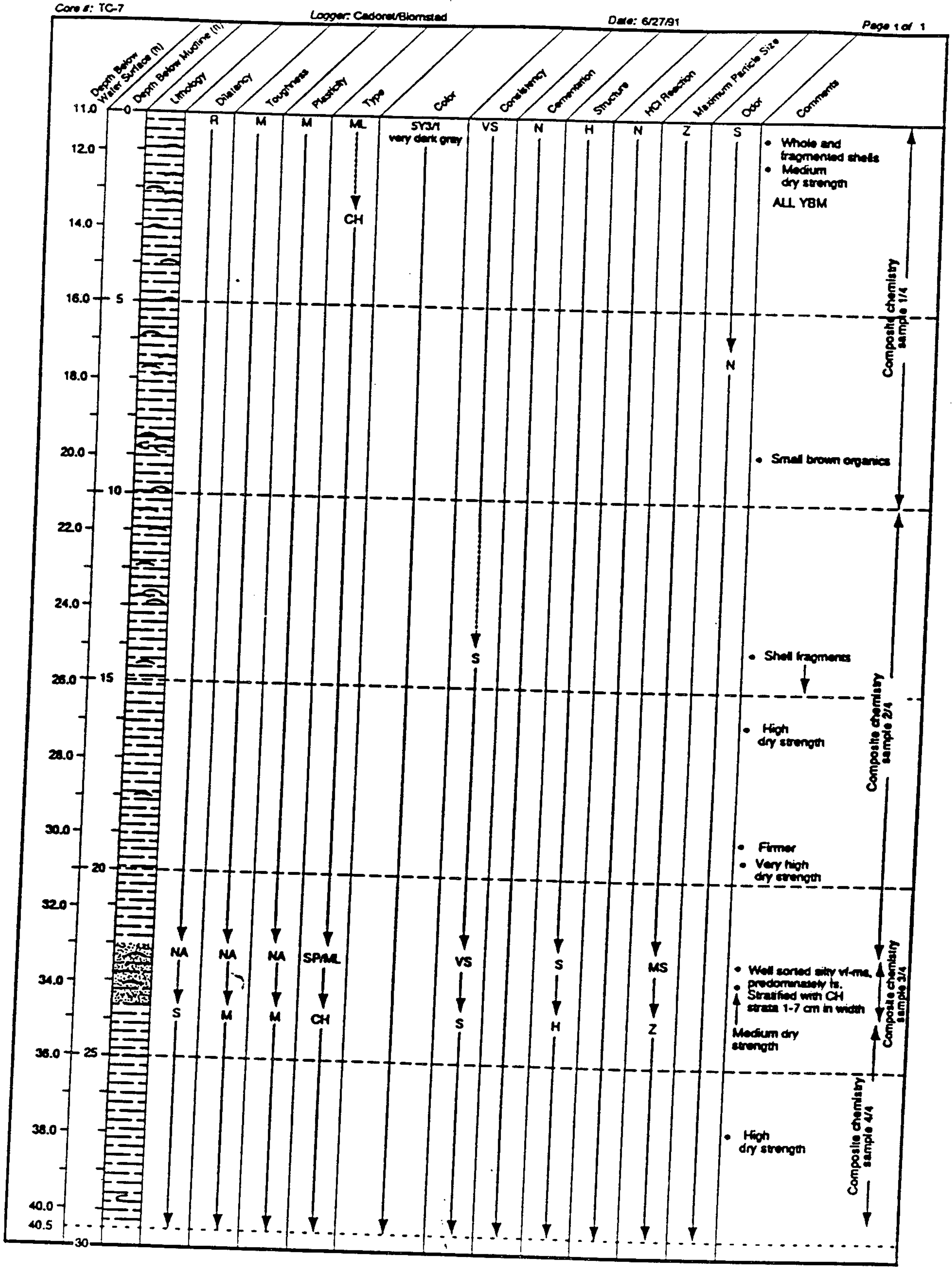


4" core

Core Data Log

Core #: TC-7 Logger: Cadoret/Blomstad Date: 6/27/91 Page 1 of 1



Core Data Log

Project: Richmond Harbor Intensive Study

Core #: UIH-1 | *Logger:* PJ White | *Date:* 2-9-94 | *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.9	0		R	M	M	CL	5Y3/1 v dark gray ↓ 2.5YN2/ black	VS	N	H	N	FS ↓ VFS	N	Sed Chem	
-40	3.1														
-40.2	3.3		NA	NA	NA	ML	5Y3/1 v dark gray	F H	N	H	N	VFS	N	OBM	YBM OBM whitish alteration in OBM -calcite
-42	5.1														OBM sample -40.2 to -42'

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: UIH-2 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-40	0 – 4.7		R	M	M	CL	5Y3/1 v dark gray → 2.5YN2/ black – 5Y3/1 v dark gray	VS → S	N	H	N	FS → VFS → MS → VFS → Z	N → P → N	Sed Chem	fragments of plant material - piling?
-42	4.7 – 6.7		NA	NA	NA	ML	5Y4/2 olive gray	F	N	H	N	Z	N	OBM	YBM / OBM

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: UIH-3 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-37.3	0		R	M	M	CL	5Y3/1 v dark gray → 2.5YN2/ black	VS → S	N	H	N	FS → VFS	N	Sed Chem	
-40	2.7		↓	↓	↓	↓	↓	↓	↓	↓	↓	→ FS	↓		OBM clast
-42	4.7														OBM clasts in YBM

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: UIH-4 *Logger:* PJ White *Date:* 2-9-94 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-34.4	0		R	M	M	CL	5Y3/1 v dark gray	VS → S	N	H	N	FS → VFS	N	Sed Chem	
-38.9	4.5		NA	NA	NA	ML	5Y4/1 dark gray	H	N	H	N	Z	N		YBM / OBM
-40	5.6													OBM	patches of whitish alteration - calcite
-41.5	7.1														

Core Data Log

Project: Richmond Harbor Intensive Study

Core #: UIH-5 *Logger:* PJ White *Date:* 2-9-94

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36 to -40	0 to 4		R	M	M	CL	5Y3/1 v dark gray	VS	N	H	N	FS → VFS → FS	N	Sed Chem	YBM
-40 to -42	4 to 6		NA	NA	NA	ML	5Y4/1 dk gray	H	N	H	N	VFS	N	OBM	OBM

DRAFT RH-DEEPENING

Hole No. P-1

DRILLING LOG	DIVISION: SOUTH PACIFIC	INSTALLATION: SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT: RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT: 6" Rotary Wash
2. LOCATION (Coordinates or Station): 516,716 N 1,462,110 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): Mean Lower Low Water (MLLW)
3. DRILLING AGENCY: Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 truck-mounted, on barge.
4. HOLE NO. (As shown on drawing title and file number): Probe-1 (P-1)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES: -0-
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 28 Jan 86; COMPLETED 28 Jan 86
7. THICKNESS OF OVERBURDEN: 20.6 Feet	17. ELEVATION TOP OF HOLE: -27.8 Feet MLLW
8. DEPTH DRILLED INTO ROCK: 3.4 Feet	18. TOTAL CORE RECOVERY FOR BORING: None -0- %
9. TOTAL DEPTH OF HOLE: 24.0 Feet	19. SIGNATURE OF INSPECTOR: Subsurface Consultants

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-27.8 MLLW	0		CLAY Black, silty, very soft, saturated, high plasticity			
	5		CLAY Brown, silty, very stiff, saturated, low plasticity			
	10					
	15					
			SAND Blue-Gray, clayey, dense, saturated			
-48.4	20		SANDSTONE Gray Brown intensely fractured, moderately weathered			
-51.8			Bottom of Hole at 24 feet			

APP. B A PLATE 10A

Hole No. P-2

DRILLING LOG	DIVISION SOUTH PACIFIC	INSTALLATION SAN FRANCISO DISTRICT	SHEET OF SHEETS

1. PROJECT RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT 6-inch Wash Boring
2. LOCATION (Coordinates or Station) 516,679 N 1,462,525 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) Mean Lower Low Water (MLLW)
3. DRILLING AGENCY Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 truck mounted on Barge
4. HOLE NO. (As shown on drawing title and file number) Probe-2 (P-2)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 28 Jan 86; COMPLETED 28 Jan 86
7. THICKNESS OF OVERBURDEN 16.5 Feet	17. ELEVATION TOP OF HOLE -35 feet MLLW
8. DEPTH DRILLED INTO ROCK 5.5 Feet	18. TOTAL CORE RECOVERY FOR BORING None 0 %
9. TOTAL DEPTH OF HOLE 22.0 feet	19. SIGNATURE OF INSPECTOR Subsurface Consultants

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-35.0 MLLW	0		CLAY Gray Black, silty, very soft, saturated, high Plasticity.			
	5		GRAVEL Blue Gray, sandy, silty (well graded), dense, rounded to subangular, saturated.			
	10		GRAVEL Brown, sandy (well graded), dense, predominately 1/8 to 1/4 inch diameter gravel, subangular to subrounded.			
-51.5	15					
-55.0	20		SANDSTONE Orange Brown and Black with Thin interbedded shale, intensely fractured, moderately hard, deeply weathered.			
			Bottom of Hole at 22 feet			

Hole No. P-3

DRILLING LOG	DIVISION SOUTH PACIFIC	INSTALLATION SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT: RICHMOND INNER HARBOR
2. LOCATION (Coordinates or Station): 517,120 N 1,462,825 E
3. DRILLING AGENCY: Pitcher Drilling Co.
4. HOLE NO. (As shown on drawing title and file number): Probe - 3 (P-3)
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 22 Feet
8. DEPTH DRILLED INTO ROCK: 0
9. TOTAL DEPTH OF HOLE: 22 Feet
10. SIZE AND TYPE OF BIT: 6" Rotary Wash
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): Mean Lower Low Water (MLLW)
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 truck-mounted on barge
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 0
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 28 Jan '86 | COMPLETED 28 Jan '86
17. ELEVATION TOP OF HOLE: -35 Feet MLLW
18. TOTAL CORE RECOVERY FOR BORING: None 0 %
19. SIGNATURE OF INSPECTOR: Subsurface Consultants

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-35.0 MLLW	0		CLAY Black, silty, very soft, saturated, high plasticity			
	5					
	10					
			CLAY Blue Gray, silty, stiff saturated, may range from low to high plasticity.			
	15					
	20					
-57.0 MLLW			Bottom of Hole at 22 feet.			

APP. ~~B~~A PLATE 10C

Hole No. P-4

DRILLING LOG	DIVISION SOUTH PACIFIC	INSTALLATION SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT 6-inch Rotary Wash
2. LOCATION (Coordinates or Station) 516,699 N 1,462,666 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) Mean Lower Low Water (MLLW)
3. DRILLING AGENCY Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 truck-mounted on barge
4. HOLE NO. (As shown on drawing title and file number) Probe-4 (P-4)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 06 Feb 1986; COMPLETED 06 Feb. 1986
7. THICKNESS OF OVERBURDEN 7.5 Feet	17. ELEVATION TOP OF HOLE -40.0 MLLW
8. DEPTH DRILLED INTO ROCK 1.0 Foot	18. TOTAL CORE RECOVERY FOR BORING None 0 %
9. TOTAL DEPTH OF HOLE 8.5 Feet	19. SIGNATURE OF INSPECTOR Subsurface Consultants

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-40.0 MLLW	0		CLAY Blue Black, silty, soft, saturated, high plasticity.			
	5		GRAVEL Brown, sandy, well-graded, medium dense, saturated			
-47.5			SANDSTONE Light Gray and Orange Brown intensely fractured, deeply weathered.			
-48.5 MLLW			Bottom of Hole at 8.5 Feet			

APP. A PLATE 10D

Hole No. P-5

DRILLING LOG	DIVISION: SOUTH PACIFIC	INSTALLATION: SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT: RICHMOND INNER HARBOR
2. LOCATION (Coordinates or Station): 516,783 N 1,462,839 E
3. DRILLING AGENCY: Pitcher Drilling Co.
4. HOLE NO. (As shown on drawing title and file number): Probe-5 (P-5)
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 2 Feet
8. DEPTH DRILLED INTO ROCK: 3.5 Feet
9. TOTAL DEPTH OF HOLE: 5.5 Feet
10. SIZE AND TYPE OF BIT: 6-inch Rotary Wash
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): Mean Lower Low Water (MLLW)
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 truck-mounted on barge
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 0
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 06 Feb 1986 | COMPLETED 06 Feb 1986
17. ELEVATION TOP OF HOLE: -43.5 Feet MLLW
18. TOTAL CORE RECOVERY FOR BORING: None 0 %
19. SIGNATURE OF INSPECTOR: Subsurface Consultants

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-43.5 MLLW	0		CLAY Blue Black, silty, soft, saturated, high plasticity			
			SHALE Orange Brown and Light Gray, interbedded with sandstone, thin bedded, intensely fractured, deeply weathered.			
-49.5 MLLW	5					
			Bottom of Hole at 5.5 Feet			

APP. A PLATE 10E

Hole No. P-6

DRILLING LOG	DIVISION: SOUTH PACIFIC	INSTALLATION: SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT: RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT: 6-inch Rotary Wash
2. LOCATION (Coordinates or Station): 516,941 N 1,462,827 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): Mean Lower Low Water (MLLW)
3. DRILLING AGENCY: Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 truck-mounted on barge
4. HOLE NO. (As shown on drawing title and file number): Probe-6 (P-6)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 05 Feb. 1986; COMPLETED 05 Feb 1986
7. THICKNESS OF OVERBURDEN: 14 Feet	17. ELEVATION TOP OF HOLE: -38.0 Feet MLLW
8. DEPTH DRILLED INTO ROCK: 7 Feet	18. TOTAL CORE RECOVERY FOR BORING: None 0 %
9. TOTAL DEPTH OF HOLE: 21 Feet	19. SIGNATURE OF INSPECTOR: Subsurface Consultants

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-38.0 MLLW	0		CLAY Blue Gray, silty, very soft, saturated.			
	5					
	10		CLAY Blue Gray, silty, stiff, saturated, low to high plasticity.			
-52.0 MLLW	15		SHALE Blue Black, thinly bedded, intensely fractured moderately hard to moderately soft, deeply weathered.			
-59.0 MLLW	20					
			Bottom of Hole at 21 Feet			

APP. ~~B~~A PLATE 10F

Hole No. P-7

DRILLING LOG	DIVISION: SOUTH PACIFIC	INSTALLATION: SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT: RICHMOND INNER HARBOR
2. LOCATION (Coordinates or Station): 516,800 N 1,462,263 E
3. DRILLING AGENCY: Pitcher Drilling Co.
4. HOLE NO. (As shown on drawing title and file number): Probe-7 (P-7)
5. NAME OF DRILLER: Pitcher Drilling Co.
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 16 feet
8. DEPTH DRILLED INTO ROCK: 3.5 feet
9. TOTAL DEPTH OF HOLE: 19.5 feet
10. SIZE AND TYPE OF BIT: 6-inch Rotary Wash
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): Mean Lower Low Water (MLLW)
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 truck-mounted on barge
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: Ø
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 06 Feb. 1986 | COMPLETED 06 Feb 1986
17. ELEVATION TOP OF HOLE: -17.0 Feet MLLW
18. TOTAL CORE RECOVERY FOR BORING: None Ø %
19. SIGNATURE OF INSPECTOR: Subsurface Consultants

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-17.0 MLLW	0		CLAY Blue Gray, silty, soft, saturated, high plasticity.			
-29.0 MLLW	12		CLAY Brown, silty, very stiff, saturated, high to low plasticity.			
-33.0 MLLW	16		SANDSTONE Orange Brown to Black, moderately hard to moderately soft, intensely fractured. SHALE, thinly bedded. SANDSTONE as above.			
-36.5 MLLW	19.5		Bottom of Hole at 19.5 feet			

Hole No. 1F-86-1

DRILLING LOG	DIVISION: SOUTH PACIFIC	INSTALLATION: SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT: RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT: 4.0-inch Diamond Core
2. LOCATION (Coordinates or Station): 516,639 N 1,461,294	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): Mean Lower Low Water (MLLW)
3. DRILLING AGENCY: Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 Truck-mounted on barge
4. HOLE NO. (As shown on drawing title and file number): 1F-86-1	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER:	14. TOTAL NUMBER CORE BOXES: 2
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER:
	16. DATE HOLE: STARTED 04 Feb. 1986 COMPLETED 04 Feb. 1986
7. THICKNESS OF OVERBURDEN: 2.5 feet	17. ELEVATION TOP OF HOLE: -34.0 Feet MLLW
8. DEPTH DRILLED INTO ROCK: 17.5 feet	18. TOTAL CORE RECOVERY FOR BORING: 7.4 feet, 42 %
9. TOTAL DEPTH OF HOLE: 20.0 Feet	19. SIGNATURE OF INSPECTOR: Relogged by Kenneth Harrington

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-34.0 MLLW	0		CLAY Blue Black, silty, soft, saturated, high plasticity. Top of Rock at 2.5 Feet			
-36.5			SHALE Gray Brown and Orange Brown, thinly bedded, intensely fractured, deeply weathered, weak.		Box 1 of 2	2" penetration of modified Cal. Sampler 2.5" diam. 50 blows of 345 lb wire line hammer.
	5		SANDSTONE Grayish Brown to Brown; medium to fine grained graywacke, moderately weathered, moderately hard, closely fractured.			Rec 2.0, cored 6.5 ft, 31% Rec. Longest piece 0.25 feet. Core loss distributed over the run.
	10		11.0 feet 1 inch shale bed dipping 75°			Rec 2.2 ft, cored 5 ft 44% Rec. Longest piece 0.55 feet, 4 pieces > 0.4 feet core loss distributed over the run. Many recovered frags rounded why drilling
	15		10-12 feet, intensely fractured, most fragments range from 3/4 inch to 1/4 inch diameter. 18 feet, thin shale bed, 0.1 ft. dark gray to black. 15-20 feet, medium to coarse grained, brownish gray to med gray.		Box 2 of 2	Rec. 3.0 ft, cored 5.0 ft, Rec. 60%, Longest piece 0.55 ft, 4 pieces > 0.33 feet Core loss distributed over run.
-54.0 MLLW	20		Bottom of Hole at 20 feet			

APP. 8A PLATE 11A

Hole No. 1F-86-2

DRILLING LOG	DIVISION SOUTH PACIFIC	INSTALLATION SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT Pitcher Barrel w/ 3" Shelby Tube
2. LOCATION (Coordinates or Station) 516,677 N 1,461,832 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) Mean Lower Low Water (MLLW)
3. DRILLING AGENCY Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL failing 1500 Truck-mounted on barge
4. HOLE NO. (As shown on drawing title and file number) 1F-86-2	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN 9.0 feet	17. ELEVATION TOP OF HOLE −28.6 MLLW
8. DEPTH DRILLED INTO ROCK 16.0 feet	18. TOTAL CORE RECOVERY FOR BORING 6.8 Feet 42%
9. TOTAL DEPTH OF HOLE 25.0 feet	19. SIGNATURE OF INSPECTOR Relogged by Kenneth G. Harrington

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
−28.6 MLLW	0		CLAY Dark Gray Black, silty, soft, saturated, high plasticity, organic oder.			
	5		SAND Brown, silty, very dense, medium-grained, Saturated Top of Rock at 9feet			
−37.6						Coring with Pitcher Barrel.
	10		SANDSTONE Brown, highly weathered to decomposed, 0.03 ft clay seam at 9.7 feet. moderately fractured. 12-15 feet decomposed Sandstone with an irregular, thin interbed of shale at 14.6 feet		Box 1 of 2	Recov. 2.6 ft, 3.0 cored, 86% Recov. Longest Piece 1.6 ft. Core lost at Top of run. Recov 1.6 feet, 3.0 feet cored 53% recov. Longest Piece 1.6 feet. Core loss DOR.
	15		SHALE Light to Very light Gray, low hardness, highly weathered possibly hydrothermally leached, irregular iron stained fractures, week to very week.		Box 2 of 2	Recov 0.75 feet, cored 3.0 feet, 25% Recov., Longest piece 0.5 foot. Core loss DOR.
	20					Recov 1.0 foot, cored 3.0 feet, 33% Recov., Longest Piece 0.6 foot., Core loss DOR.
−53.6 MLLW	25		SANDSTONE Grayish Brown to Brown, medium to fine-grained graywacke, moderately weathered. Moderately hard, very closely fractured.			Recov. 0.8 feet, cored 3.0 feet 27% Recov. Longest Piece 0.2 foot, Core loss DOR.
			Bottom of Hole at 25 feet			

APP. RA PLATE 11B

Hole No. 1F-86-3

DRILLING LOG	DIVISION SOUTH PACIFIC	INSTALLATION SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT Pitcher Barrel with 3" Shelby Tube
2. LOCATION (Coordinates or Station) 516,806 N 1,462,519 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) Mean Lower Low Water (MLLW)
3. DRILLING AGENCY Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 Truck-mounted on barge
4. HOLE NO. (As shown on drawing title and file number) 1F-86-3	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES 2
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 29 Jan. 1986 — COMPLETED 29 Jan 1986
7. THICKNESS OF OVERBURDEN 6 Feet	17. ELEVATION TOP OF HOLE -34.0 Feet MLLW
8. DEPTH DRILLED INTO ROCK 14 Feet	18. TOTAL CORE RECOVERY FOR BORING 4.3 Feet 31%
9. TOTAL DEPTH OF HOLE 20 Feet	19. SIGNATURE OF INSPECTOR Relogged by Kenneth G. Harrington

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-34.0 MLLW	0		CLAY Dark Blue Black, silty, very soft, saturated, high plasticity, organic oder.			
-40.0	5		Top of Rock at 6 Feet			
			SANDSTONE Orange Brown to Light Brown, decomposed to highly weathered, low hardness, very weak, friable, occasional irregular thin bed of shale.		Box 1 of 2	4-inch penetration of modified Cal. sampler., 2.5-inch diam., 50 blows of 345 lb wire line hammer. Recov. 1.3 Feet, Cored 3.0 Feet, 43% Recov., Longest Piece 0.9 Feet, Core loss DOR
	10					Recov. 0.8 Feet, Cored 3.0 Feet, 27% Recov. Longest piece 0.35 Feet, Core loss DOR.
-48.0			At 14 Feet, Brownish Gray, moderately weathered, moderately hard, closely to very closely fractured, iron stained surfaces.		Box 2 of 2	Recov. 1.4 Feet, Cored 3.0 Feet 47% Recov., Longest piece 0.7 Foot, Core loss DOR.
	15		At 16.1 Feet moderately to highly weathered, laminated ($\geq \frac{1}{16}$ inch) sandstone, 65° dip, parts easily.			Recov. 0.5 Foot, Cored 3.0 Feet 17% Recov. Longest piece less than 2 inches.
-54.0 MLLW	20		17 to 20 Feet, Gray color with some brown internal discoloration due to weathering, moderately hard, very closely fractured, some secondary quartz veining.			
			Bottom of Hole at 20 Feet.			

APP. BA PLATE 11C

Hole No. 1F-86-4

DRILLING LOG	DIVISION SOUTH PACIFIC	INSTALLATION SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT Pitcher Barrel & 4-in i.d Diamond.
2. LOCATION (Coordinates or Station) 516,842 N 1,462,739 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) Mean Lower Low Water (MLLW)
3. DRILLING AGENCY Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 truck-mounted on barge
4. HOLE NO. (As shown on drawing title and file number) 1F-86-4	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES 2
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 03 Feb 1986 — COMPLETED 03 Feb 1986
7. THICKNESS OF OVERBURDEN 1.6 Feet	17. ELEVATION TOP OF HOLE -36.0 Feet MLLW
8. DEPTH DRILLED INTO ROCK 18.4 Feet	18. TOTAL CORE RECOVERY FOR BORING 5.6 Feet 30%
9. TOTAL DEPTH OF HOLE 20 Feet	19. SIGNATURE OF INSPECTOR Relogged by Kennith G. Harrington

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e (0–100)	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-36.0 MLLW	0		CLAY Blue Black, soft to firm. Top of Rock at 1.6 Feet			
-37.6			SANDSTONE Dark Gray to Orange Black, moderately weathered, moderately hard, Iron and manganese stained fracture surfaces, very closely fractured, some secondary quartz and calcite veining.		Box 1 of 2	1.0 to 2.0 feet Drive sample 2.5-inch diameter. Recov. 0.8 feet, 3.0 feet cored, 27% Recov. Longest piece 0.25 feet, core loss DOR.
	5					Recov. 0.25 feet, 3.0 feet cored, 8% Recov. Longest piece 0.2 feet, Core loss DOR.
	10		8.5 to 12.5 Feet, closely fractured, medium to coarse-grained sandstone with common lithics ≤ 7mm - Long demension of lithics dip 60° to 65°.		Box 2 of 2	4-inch i.d. diamond core bit Recov. 1.7 feet, 4.0 feet cored, 43% Recov., Longest piece 0.5 feet, 3 pieces ≥ 0.33 feet, Core loss DOR.
			At 13.0 feet, a shale layer 0.1 to 0.2 feet Thick.			
	15		13.2 to 20.0 feet, sandstone is closely to very closely fractured, moderately hard to low hardness, medium to coarse-grained with tabular, subrounded lithics up to 4mm.			4-inch i.d. diamond core bit Recov. 2.4 feet, 7.0 feet cored, Recov 34%, Longest piece 0.4 feet, 3 pieces ≥ 0.33 feet. Core loss Distributed Over Run (DOR).
-56.0 MLLW	20		Bottom of Hole at 20 Feet			

Hole No. 1F-86-5

DRILLING LOG	DIVISION: SOUTH PACIFIC	INSTALLATION: SAN FRANCISCO DISTRICT	SHEET OF SHEETS

1. PROJECT: RICHMOND INNER HARBOR	10. SIZE AND TYPE OF BIT: Pitcher Barrel & 4-in i.d. Diamond.
2. LOCATION (Coordinates or Station): 517,367 N 1,462,780 E	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): Mean Lower Low Water (MLLW)
3. DRILLING AGENCY: Pitcher Drilling Co.	12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 Truck-mounted on barge
4. HOLE NO. (As shown on drawing title and file number): 1F-86-5	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES: 2
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 30 Jan. 1986; COMPLETED 30 Jan 1986
7. THICKNESS OF OVERBURDEN: 11.2 Feet	17. ELEVATION TOP OF HOLE: -34.0 Feet MLLW
8. DEPTH DRILLED INTO ROCK: 8.8 Feet	18. TOTAL CORE RECOVERY FOR BORING: 4.4 Feet 50 %
9. TOTAL DEPTH OF HOLE: 20.0 Feet	19. SIGNATURE OF INSPECTOR: Relogged by Kenneth G. Harrington

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e (0 • 100)	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-34.0 MLLW	0		CLAY Blue Black, silty, very, soft, saturated, organic oder, high plasticity.			
	5		At 5 feet color changes to light blue-gray, becomes stiffer			
			CLAY Dark Blue-Gray, with sand, very stiff, saturated, pebbles to 1-inch diameter		Box 1 of 2	9.0 to 12.0 feet, 3-inch Shelby tube in an Osterberg sampler. Recov. 1.6 Feet, sampled 3.0 feet, 53% core Recov.
-45.2	10		SAND Gray-Green, Poorly cemented, friable, coarse-grained.			
			Top of Rock at 11.2 Feet			
			SANDSTONE		Box 2 of 2	12.5 to 13.5 Feet, 2.5-inch brass tubes of Modified California sampler.
			11.2 to 12.0 Feet Dark Gray-Green, decomposed.			
	15		12.5 to 13.5 Feet, decomposed rock. Recov. 0.15 Foot of coarse sand with some rounded and subangular gravel up to 0.5-inch at top of interval.			13.5 to 16.5 Feet cored with a Pitcher Barrel, Recov. 1.9 Feet, cored 3.0 feet, 63% Recov. Longest piece 1.9 Feet, core loss distributed over run (DOR).
-54.0 MLLW			13.5 to 16.5 Feet, recov. 1.65 Feet of highly weathered, recemented sheared sandstone with 10 to 15% biotite, very weak, soft, friable. Contains a clast of rounded, harder schistose meta-sandstone. Recov. 0.25 Foot of moderately hard, moderately to highly weathered, iron stained sandstone.			17.0 to 20.0 Feet, 4-in. diam. core, Recov. 0.85 foot cored 3.0 feet, 28% Recov. Longest piece 0.4 foot, core loss DOR.
			17.0 to 20.0 Feet, recov. 0.6 foot of moderately weathered, moderately hard, recemented sheared sandstone. Iron staining and clay along shear joints ≤ 0.5mm spacing, dip of 25 to 30° parallel to general biotite alignment. Recov 0.25 foot of highly weathered, weak, recemented sheared sandstone.			
			Bottom of Hole at 20.0 Feet			

APP. ~~B~~ A PLATE 11E

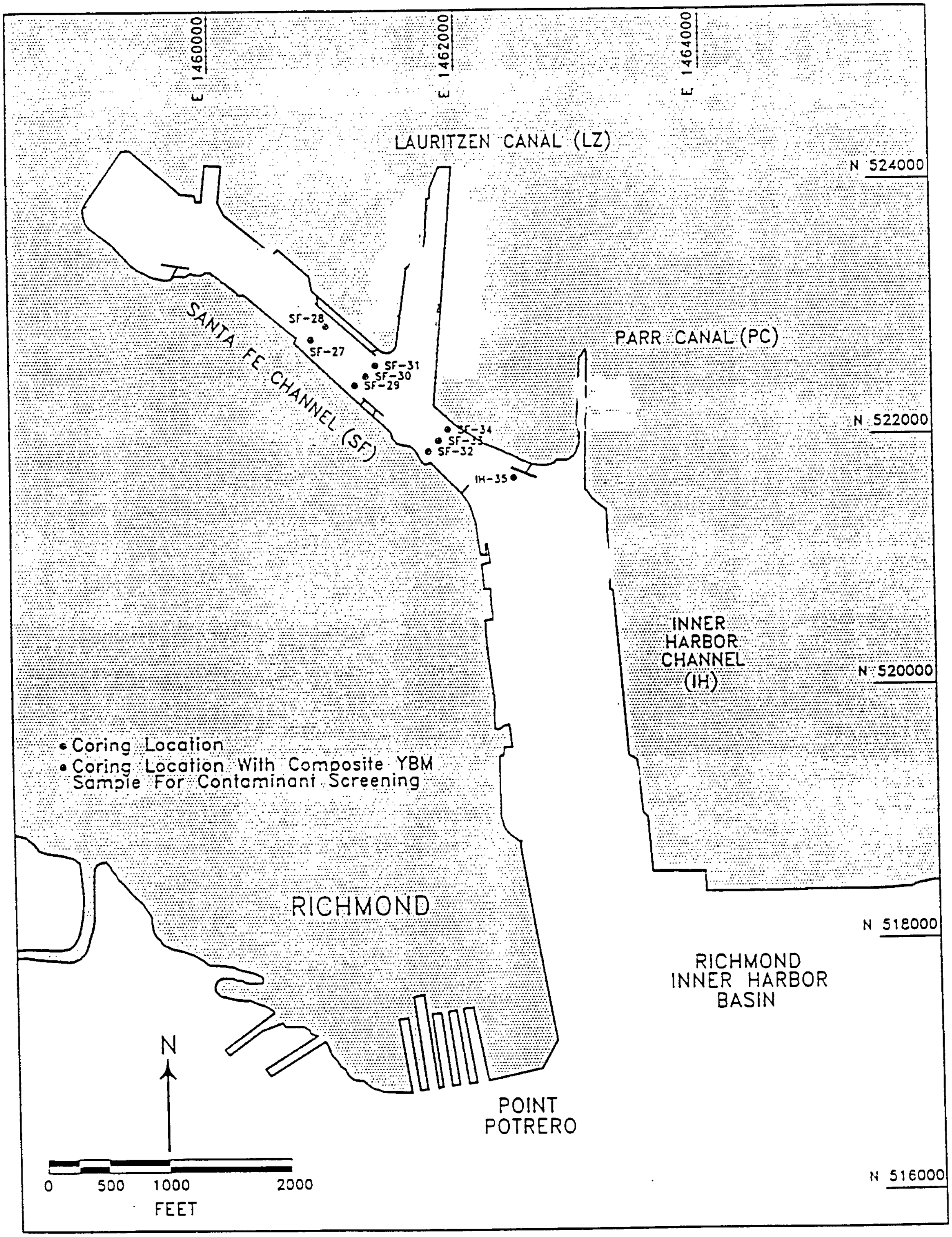


FIGURE 3.1. Core Sampling Station Designations

Core Data Log

Project: Heckathorn

Core #: SF-27 *Logger:* PJ White *Date:* 1-18-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.3	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	
-36.3	1													B	
-38.3	3													C	
-39.3	4						+ 5Y4/1 dk. gray			M				X	very dark gray CL with FS and dark gray CL with Z
-40.3	5		NA	M	M	CL	5Y4/1 dk. gray	H	N	H	N, except $CaCO_3$ alt.	Z – FS	N	Y	OBM
-41.3	6													Z	locally altered $CaCO_3$
-41.8	6.5														

Core Data Log

Project: Heckathorn

Core #: SF-28 *Logger:* PJ White *Date:* 1-18-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.6	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	faint S	A	
-36.6	1													B	
							2.5YN2/ black	S				Z	N		
-38.3	2.7													X	dark gray OBM CL clast
-39.3	3.7		NA	NA	NA	SP	5Y4/2 olive gray	F	N	H	N	CS few pebbles	N	Y	OBM
-39.8	4.2														
															photo

PLATE 12.3

Core Data Log

Project: Heckathorn

Core #: SF-29 *Logger:* PJ White *Date:* 1-18-93

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-27.1	0	λ	NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	FS	N	A	
-28.1	1	λ												B	sparse roots
															root
-30.1	3							S						C	
															shell
-32.1	5						2.5YN2/ black							D	clast of OBM- dark gray SC
												Z - FS			
-34.1	7									M, faint S				E	
												Z - pebbles ≥0.5'			
-35.9	8.8					SC/CL								X	
-36.9	9.8		NA	M	M	CL	5Y4/1 dk. gray	H	N	H	N except $CaCO_3$ alt.	Z	N	Y	OBM
-37.9	10.8													Z	local $CaCO_3$ alt. white, powdery
-38.9	11.8														
-39.7	12.6														

UHRI DRAFT

PLATE 12.4

Core Data Log

Project: Heckathorn
Core #: SF-30 *Logger:* PJ White *Date:* 1-18-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.1	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS		A	
-37.1	1											FS		B	
-37.9	1.8													X	
-38.9	2.8		NA	M	M	CL	5Y4/1 v. dark gray	F - H	N	H	N	Z		Y	→ change in consistency from F to very H
-39.9	3.8													Z	
-40.8	4.7														

Core Data Log

Project: Heckathorn

Core #: SF-31 *Logger:* PJ White *Date:* 1-18-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-36.9	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS – Z	N	A	
-37.9	1													X	
-38.9	2		NA	M	M	CL	5Y4/1 dk. gray	F – H	N	H	N	Z	N	Y	← distinct change in texture from F to very H
-39.9	3													Z	$CaCO_3$ alt.
-40.9	4														

PLATE 12.6

Core Data Log

Project: Heckathorn

Core #: SF-32 *Logger:* PJ White *Date:* 1-16-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-27.5	0		NA	NA	NA	CL	2.5YN3/ dk. gray	VS	N	H	N	VFS	faint S	A	
-28.5	1													B	clam shell fragments
													rubbery smell		many roots
-30.5	3											FS	N	C	
-32.2	4.7											Z		X	
-33.2	5.7		NA	M	M	CL	5Y5/2 olive gray 5Y4/1 dk. gray	H	N	H	N, except alt.	Z	N	Y	~3" band OBM of olive gray clay over gray clay
-34.2	6.7													Z	
-35.2	7.7														$CaCO_3$ alteration -
-35.8	8.3						?								sparse, white powder surfaces

PLATE 12.7

Core Data Log

Project: Heckathorn

Core #: SF-33 *Logger:* PJ White *Date:* 1-16-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.9	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS	faint S	A	
-36.9	1													B	gas holes
													N		
-39.1	3.2													X	
	4.2														
-40.1			NA	NA	NA	SC	5Y4/1 dk. gray	F	N	H/S	N	MS	N	Y	OBM
-41.1	5.2		NA	M	M	CL		H				Z		Z	
-42.1	6.2														
-42.8	6.9														

PLATE 12.8

Core Data Log

Project: Heckathorn

Core #: SF-34 *Logger:* PJ White *Date:* 1-16-93 *Page* 1 *of* 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-38.0	0		NA	NA	NA	CL	2.5YN3/ v. dark gray	VS	N	H	N	VFS	faint S	A	
-39.0	1													B	
-39.8	1.8							VS/S						X	mixture of YBM & OBM - disrupted zone
	2.8														
-40.8			NA	M	M	CL	5Y4/1 dk. gray	F	N	H	N	Z	N	Y	OBM
-41.8	3.8													Z	
-42.2	4.2														

Core Data Log

Project: Heckathorn

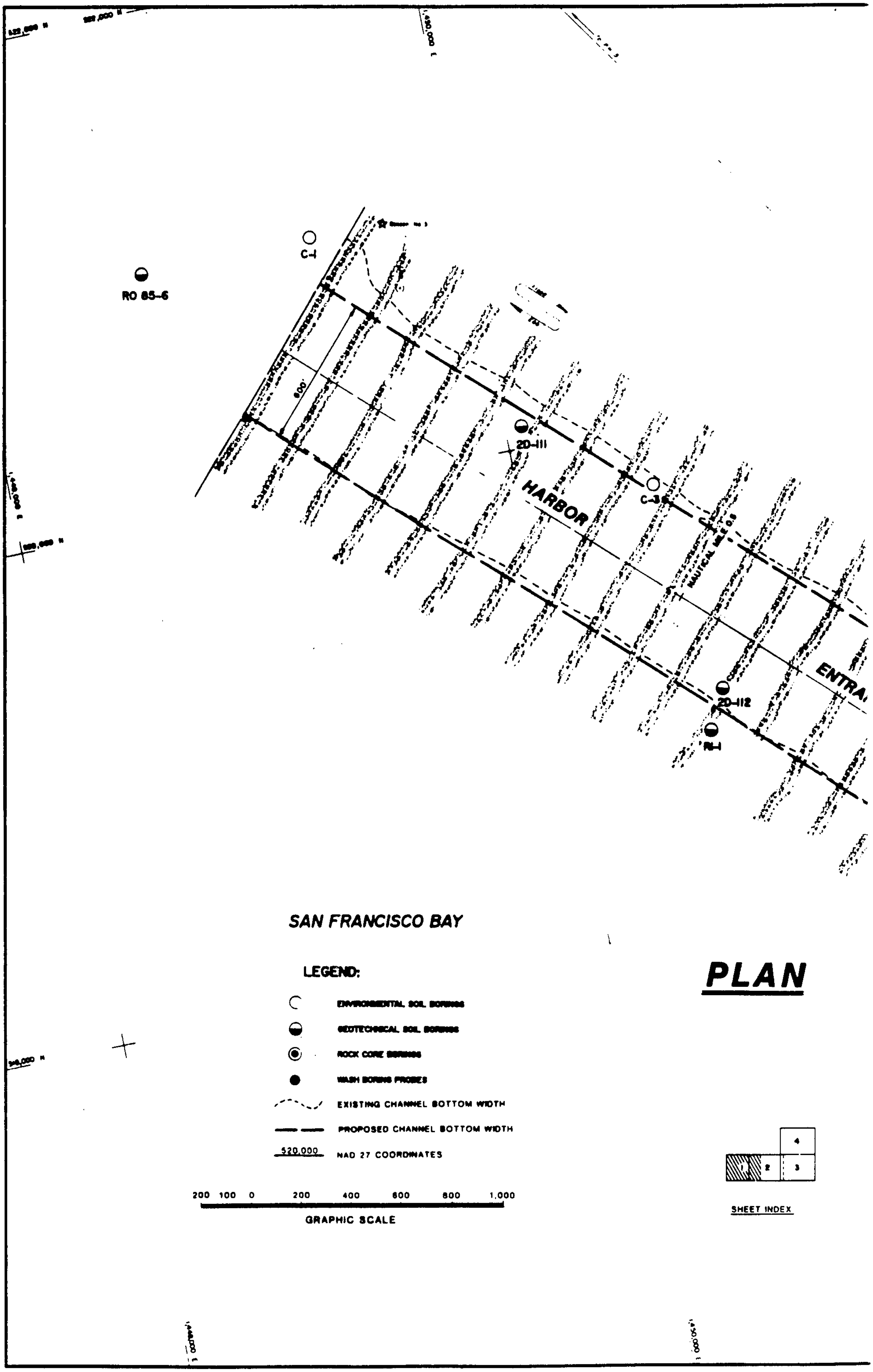
Core #: IH-35 *Logger:* PJ White *Date:* 1-19-93 *Page* 1 of 1

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Samples	Comments
-35.6	0		NA	NA	NA	CL	2.5YN3/ v. dark gray → 5Y4/1 dk. gray	VS	N	H	N	FS	N	A	
-36.6	1													X	
-38.0	2.4		NA	M	M	CL	5Y4/1 dk. gray	F - H	N	H	N	Z	N	Y	OBM
-39.0	3.4													Z	
-40.0	4.4														

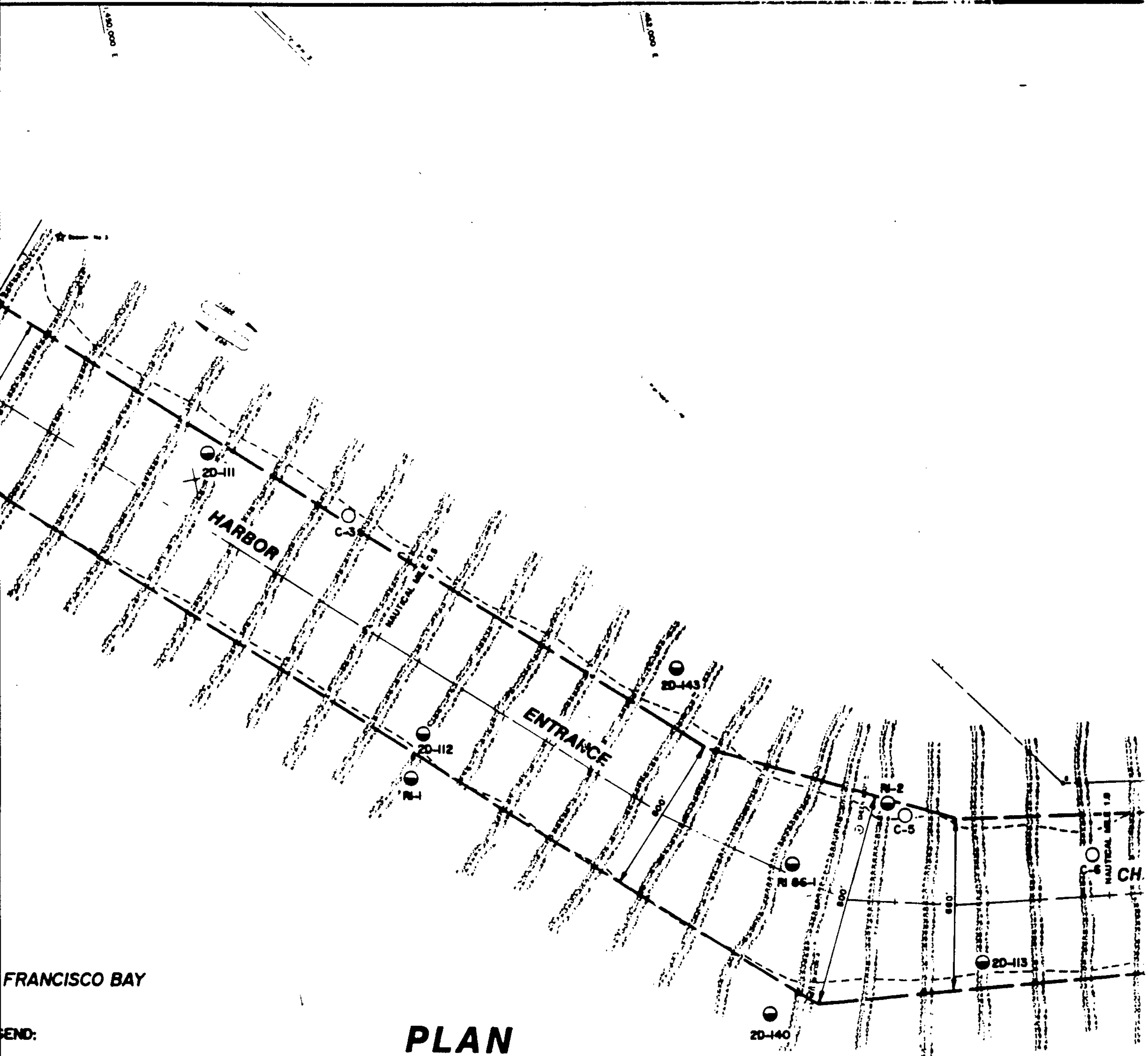
UHRI DRAFT

A.35

PLATE 12.13


RO 85-6
C-1
2D-111
C-38
HARBOR
ENTRA
NAUTICAL MILE 0.8
2D-112
RI-1
600'
SAN FRANCISCO BAY
LEGEND:
ENVIRONMENTAL SOIL BORINGS
GEOTECHNICAL SOIL BORINGS
ROCK CORE BORINGS
WASH BORING PROBES
EXISTING CHANNEL BOTTOM WIDTH
PROPOSED CHANNEL BOTTOM WIDTH
520,000 NAD 27 COORDINATES
200 100 0 200 400 600 800 1,000
GRAPHIC SCALE
PLAN
4
1 2 3
SHEET INDEX

1



PLAN

END:

ENVIRONMENTAL SOIL BORINGS

GEOTECHNICAL SOIL BORINGS

ROCK CORE BORINGS

WASH BORING PROBES

EXISTING CHANNEL BOTTOM WIDTH

PROPOSED CHANNEL BOTTOM WIDTH

NAD 27 COORDINATES

400 600 800 1,000

PHIC SCALE

		4
1	2	3

SHEET INDEX

NOTES:

DRAWINGS NOT BE USED AS NAVIGATION CHARTS. DRAWINGS SHOW ONLY CHANNEL CONDITION AT DATE OF SURVEY.

THE LOCATION OF ALL NAVIGATION AIDS ARE BASED ON INFORMATION PROVIDED BY THE U.S. COAST GUARD. BUOY LOCATION REPRESENT THE POSITION OF THE SINKER ONLY.

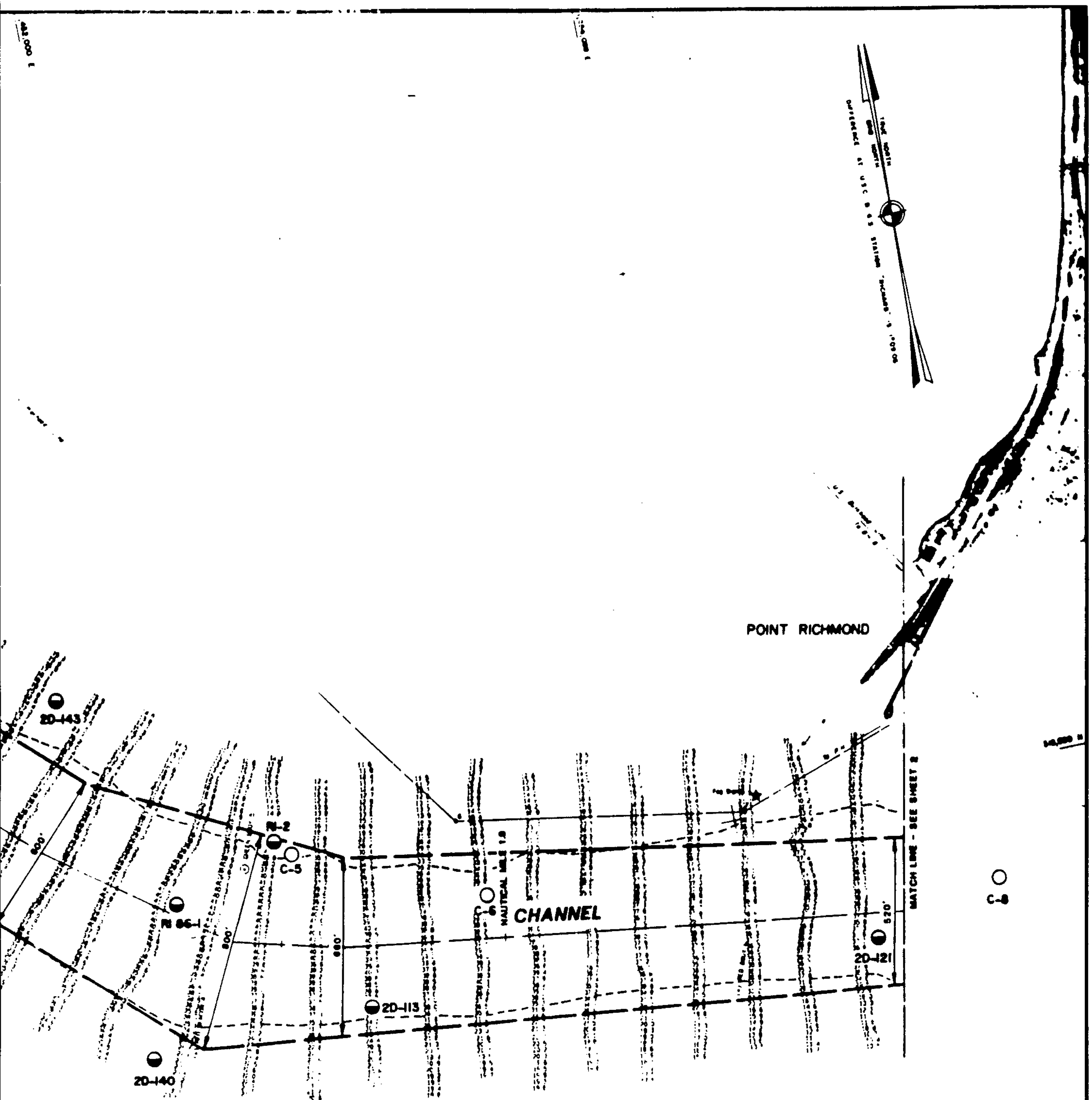
SURVEYED BY THE CORPS OF ENGINEERS: 3-8 DEC. 1994.

SOUNDINGS WERE TAKEN BY FATHOMETER AND ARE SHOWN TO THE NEAREST TENTH OF A FOOT.

SOUNDINGS ARE BASED ON THE DATUM OF MEAN LOWER LOW WATER AT THE LOCALITY AND ARE REFERENCED TO U.S. & G. S. BENCH MARK 'TITLE 2', ELEVATION 15.47 MLLW AT THE TIBURON NAVEL NET DEPOT.

PLANE GRID, BEARINGS AND COORDINATES ARE BASED ON THE STATE OF CALIFORNIA COORDINATE SYSTEM (LAMBERT CONFORMAL PROJECTION) ZONE III, CALIFORNIA, AS DESCRIBED IN SPECIAL PUBLICATION NO. 253, PUBLISHED BY THE NATIONAL OCEAN SURVEY.

DATE OF PHOTOGRAPHY: SEPTEMBER 21, 1985.



OTES:

WINGS NOT BE USED AS NAVIGATION CHARTS. DRAWINGS SHOW
Y CHANNEL CONDITION AT DATE OF SURVEY.

LOCATION OF ALL NAVIGATION AIDS ARE BASED ON
RMATION PROVIDED BY THE U.S. COAST GUARD.
Y LOCATION REPRESENT THE POSITION OF THE SINKER ONLY.

EYED BY THE CORPS OF ENGINEERS: 3-8 DEC. 1994.

NDINGS WERE TAKEN BY FATHOMETER AND ARE SHOWN TO THE
EST TENTH OF A FOOT.

NDINGS ARE BASED ON THE DATUM OF MEAN LOWER LOW WATER
HE LOCALITY AND ARE REFERENCED TO U.S. & G. S. BENCH
K "TITLE 2", ELEVATION 15.47 MLLW AT THE TIBURON NAVEL
DEPOT.

E GRID, BEARINGS AND COORDINATES ARE BASED ON THE STATE
ALIFORNIA COORDINATE SYSTEM (LAMBERT CONFORMAL PROJECTION)
E III, CALIFORNIA, AS DESCRIBED IN SPECIAL PUBLICATION
253, PUBLISHED BY THE NATIONAL OCEAN SURVEY.

E OF PHOTOGRAPHY: SEPTEMBER 21, 1985.

SYMBOL	DESCRIPTION	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DESIGNED BY: P H
TRACED BY:
CHECKED BY: K.H
SUBMITTED:
PROJECT COORDINATOR

CONTRA COSTA COUNTY — CALIFORNIA

RICHMOND HARBOR (PHASE I)

RECOMMENDED PLAN

DEEPENING TO -38 FEET MLLW

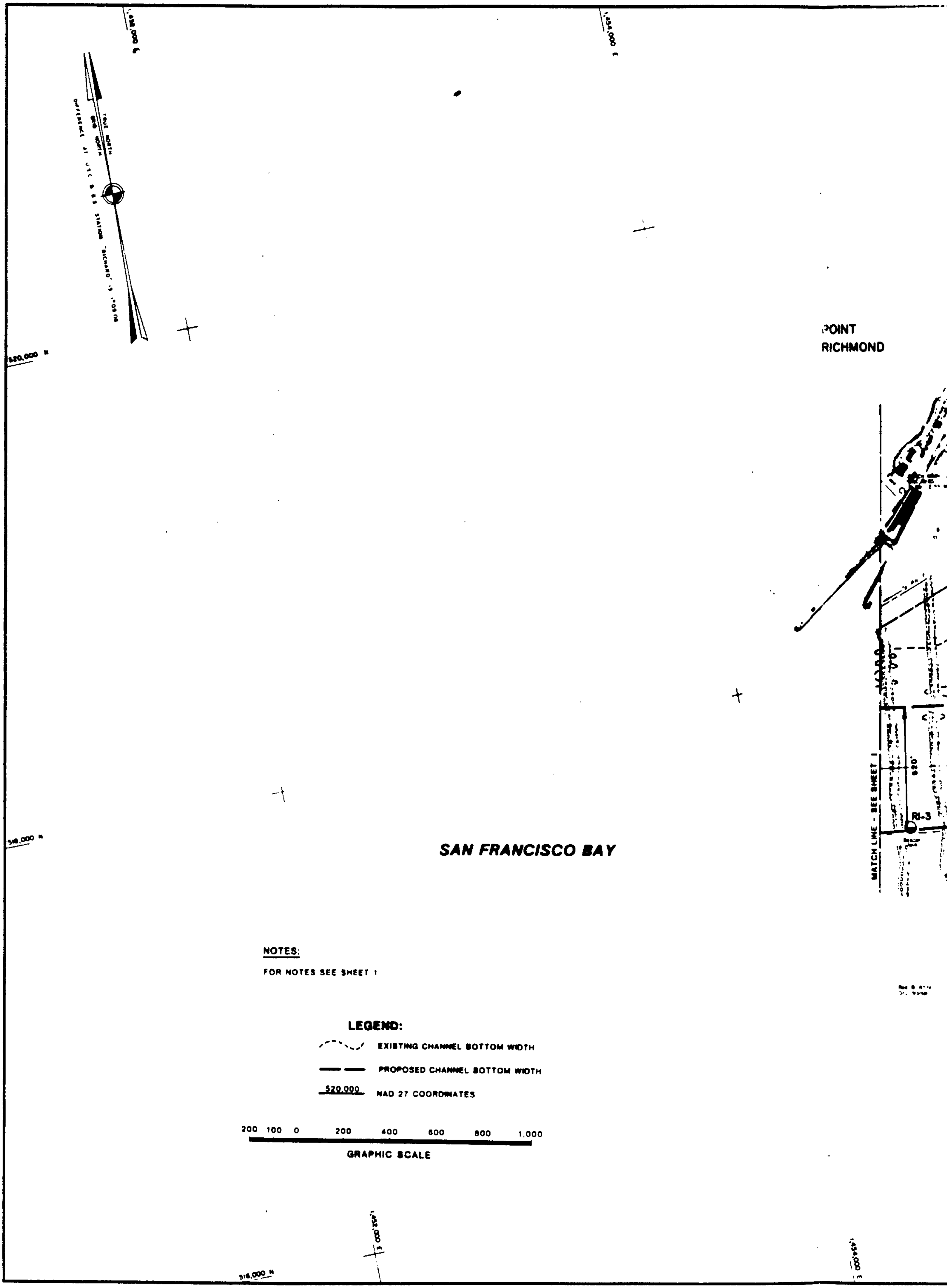
APPROVAL RECOMMENDED:
APPROVED: DATE

PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E., DISTRICT ENGINEER

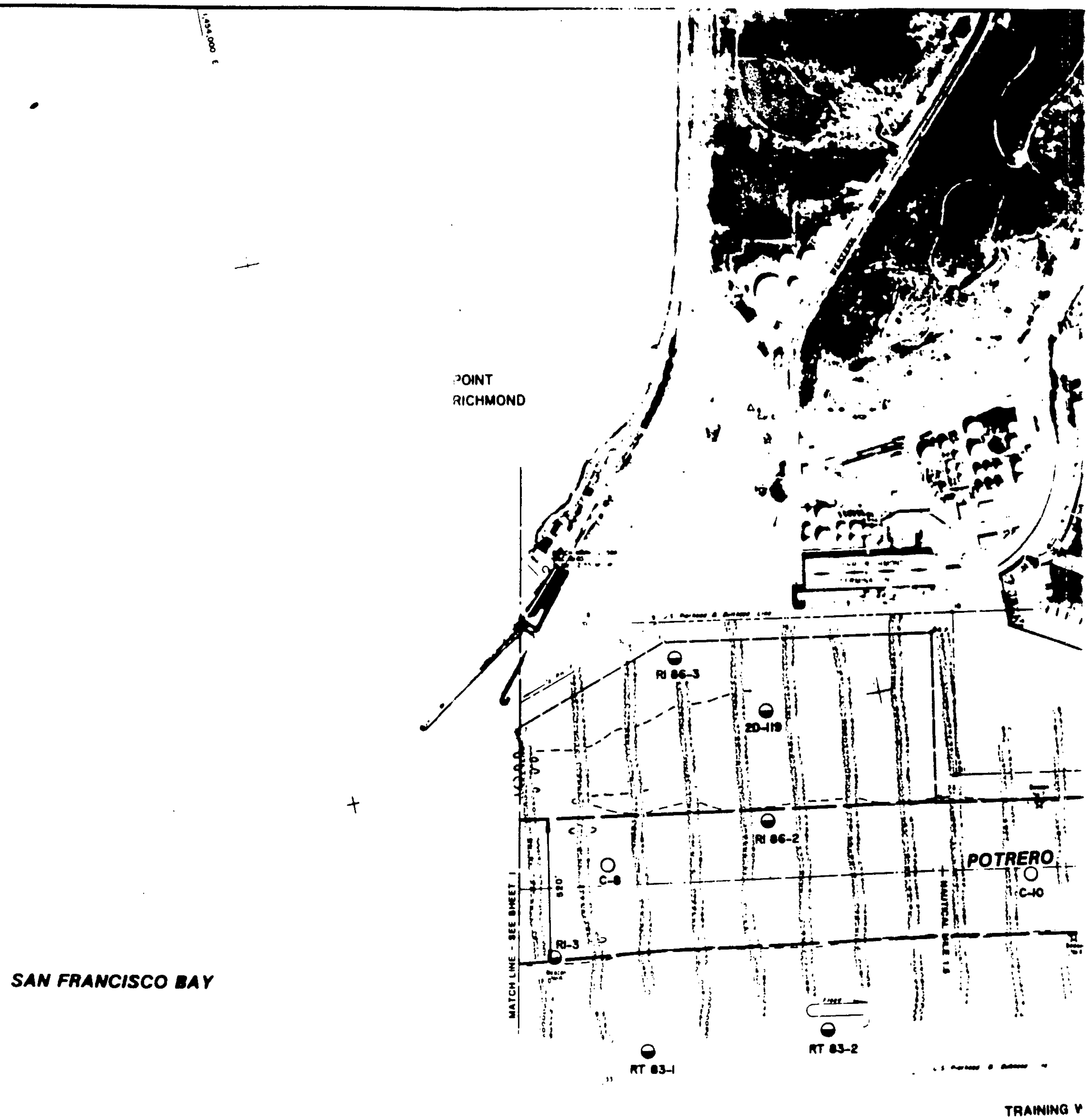
SCALE 1" = 200'
JOB No.
DRAWING NUMBER
SHEET 1 OF 4

APP. B PLATE I

3



POINT
RICHMOND
SAN FRANCISCO BAY
MATCH LINE - SEE SHEET 1
RI-3
520,000 N
518,000 N
516,000 N
1,454,000 E
1,452,000 E
NOTES:
FOR NOTES SEE SHEET 1
LEGEND:
EXISTING CHANNEL BOTTOM WIDTH
PROPOSED CHANNEL BOTTOM WIDTH
520,000 NAD 27 COORDINATES
200 100 0 200 400 600 800 1,000
GRAPHIC SCALE



ET 1

EGEND:

EXISTING CHANNEL BOTTOM WIDTH

PROPOSED CHANNEL BOTTOM WIDTH

NAD 27 COORDINATES

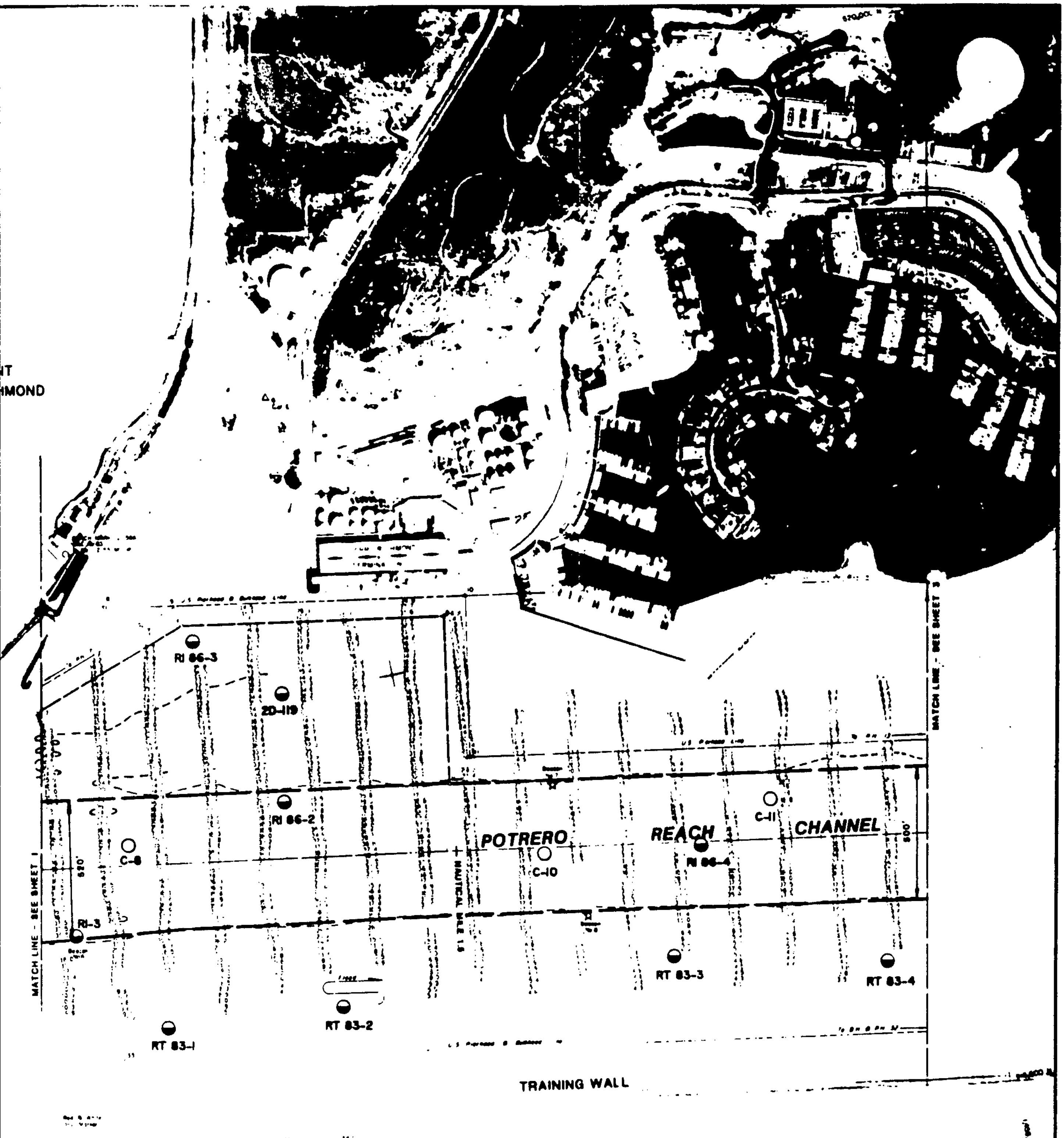
400 600 800 1,000

APHIC SCALE

PLAN

		4
1	2	3

SHEET INDEX



PLAN

4

1	2	3

SHEET INDEX

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DESIGNED BY: PH

CONTRA COSTA COUNTY CALIFORNIA

RICHMOND HARBOR (PHASE I)

RECOMMENDED PLAN

DEEPENING TO -38 FEET MLLW

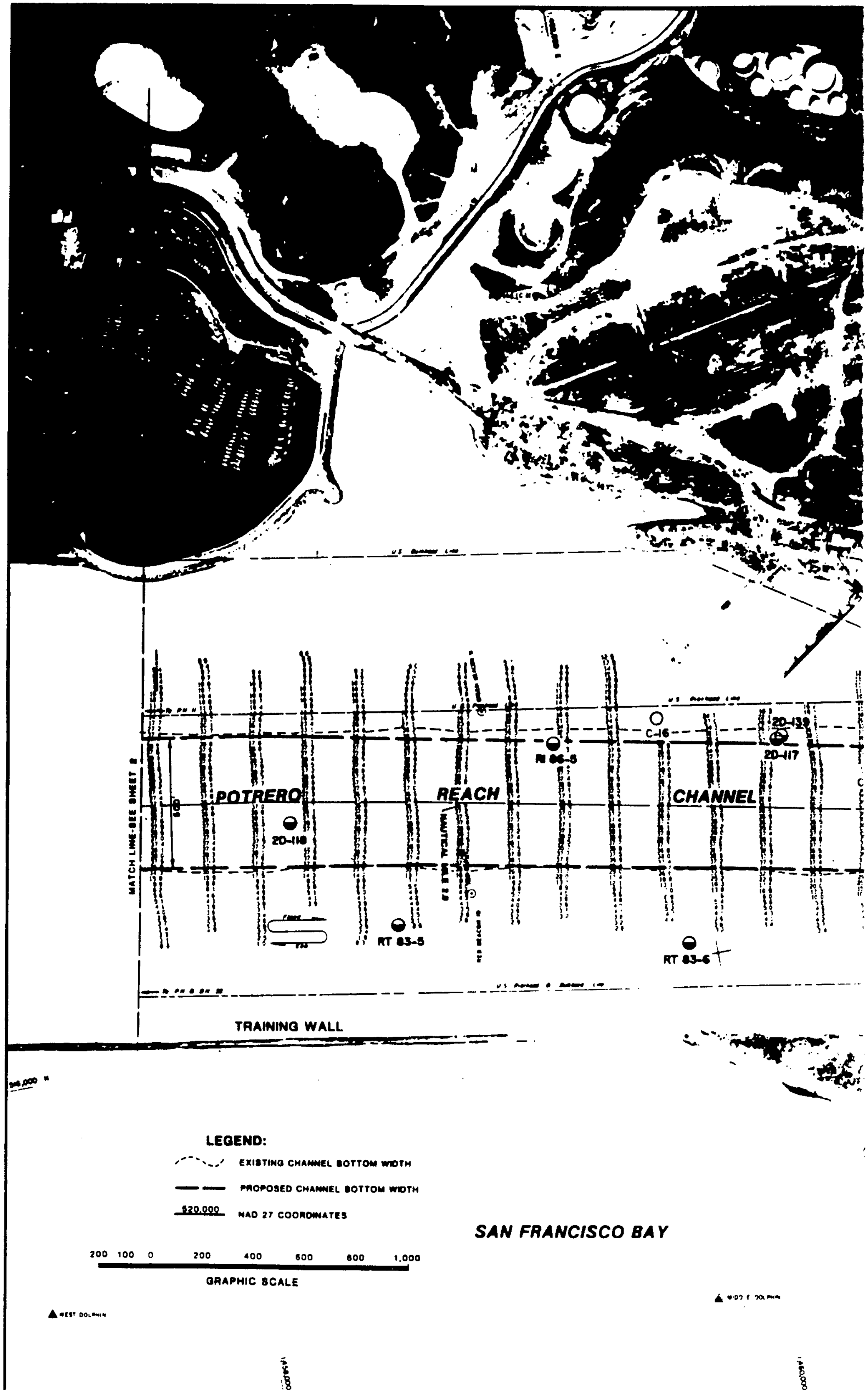
PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E. DISTRICT ENGINEER

SCALE 1" = 200'

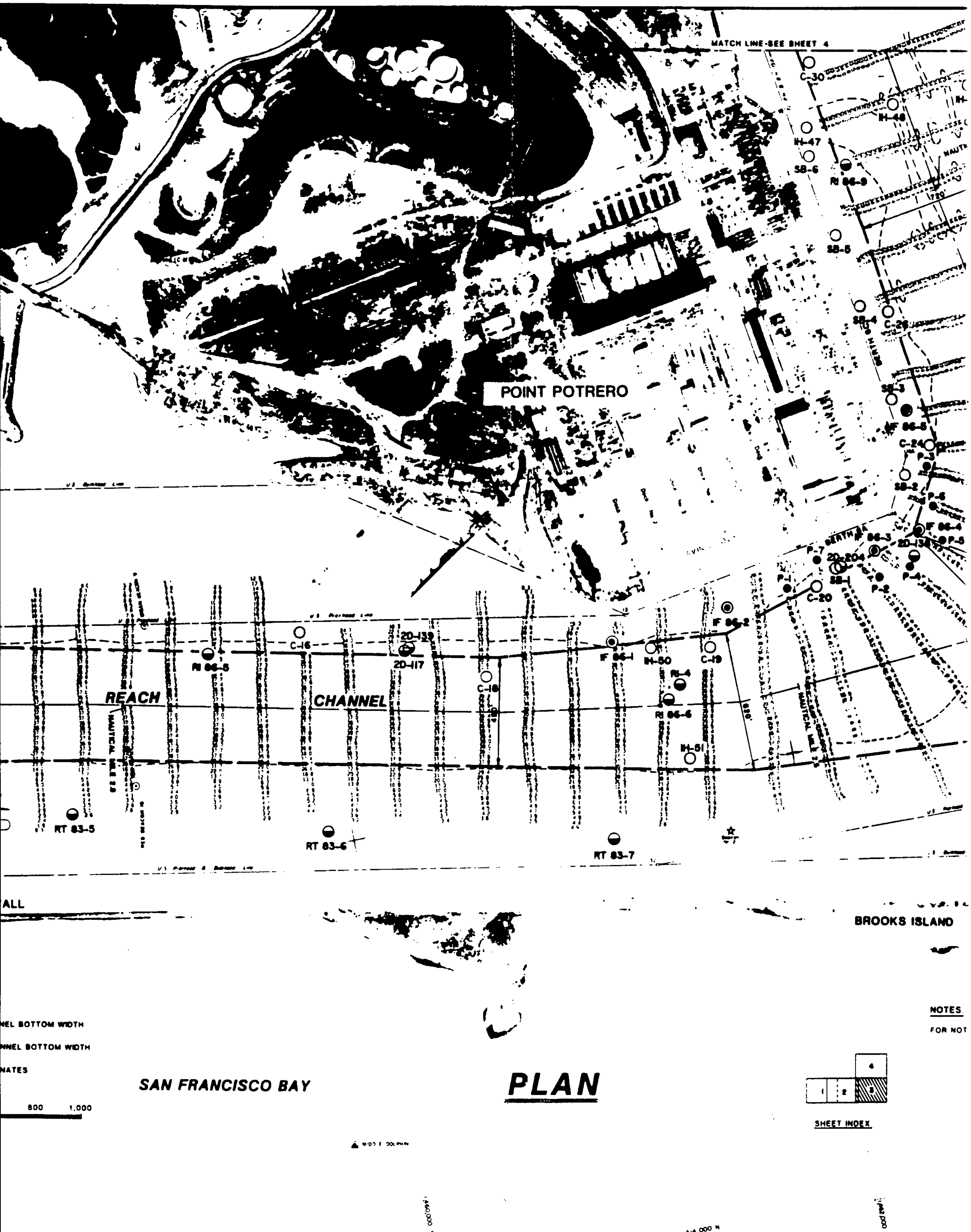
SHEET 2 OF 4

APP. B PLATE 2

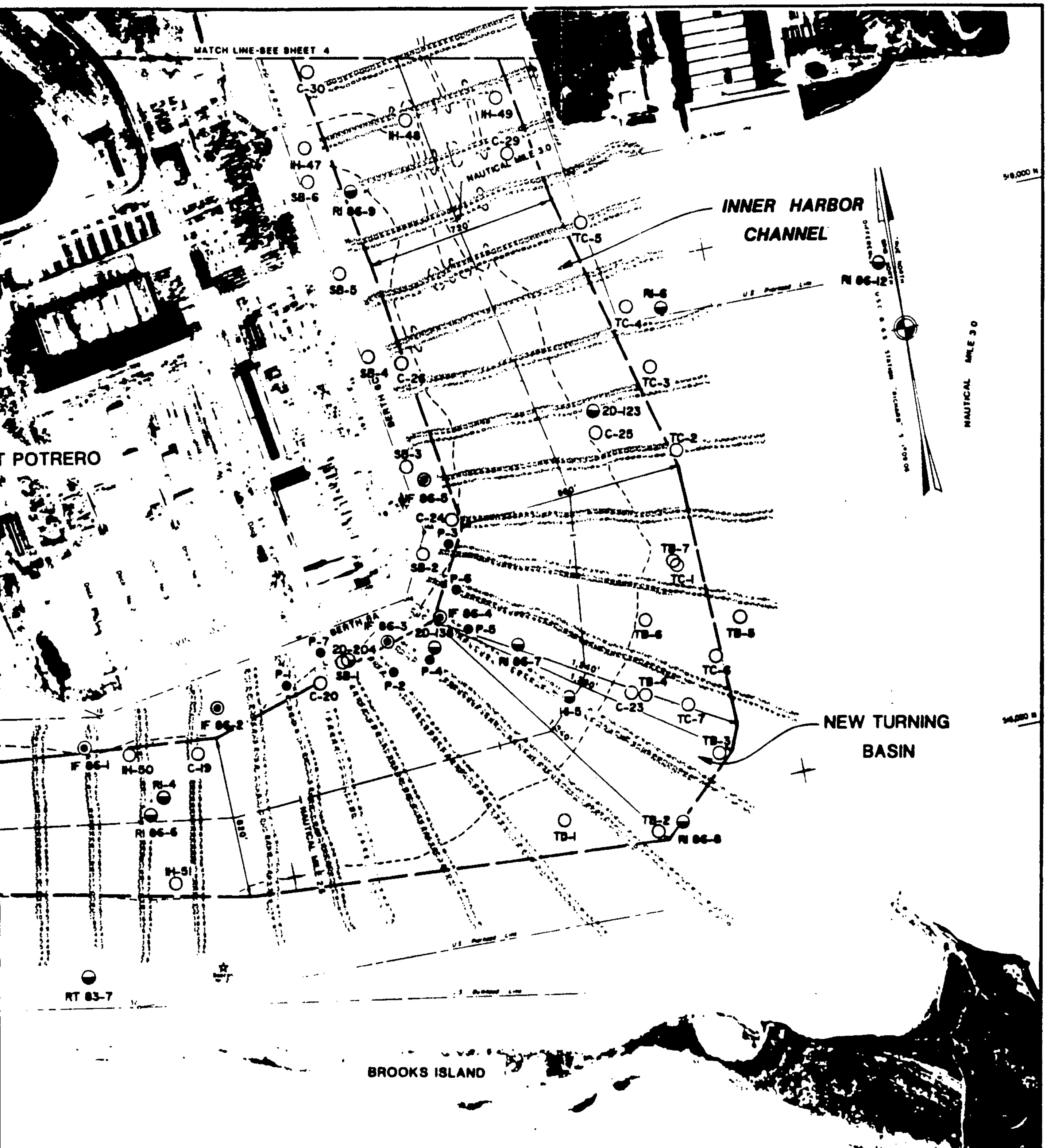
(3)



POTRERO
REACH
CHANNEL
2D-118
RT 83-5
RT 83-6
RI 86-5
C-16
2D-139
2D-117
MATCH LINE-SEE SHEET 2
TRAINING WALL
LEGEND:
EXISTING CHANNEL BOTTOM WIDTH
PROPOSED CHANNEL BOTTOM WIDTH
520,000
NAD 27 COORDINATES
SAN FRANCISCO BAY
200 100 0 200 400 600 800 1,000
GRAPHIC SCALE
WEST DOLPHIN


MATCH LINE-SEE SHEET 4
POINT POTRERO
REACH
CHANNEL
C-30
IH-47
SB-6
SB-5
SB-4
SB-3
SB-2
SB-1
C-24
C-20
C-19
C-18
C-16
IH-50
IH-51
RI 86-5
RI 86-6
RI-4
20-139
20-117
20-204
IF 86-1
IF 86-2
IF 86-3
IF 86-4
P-1
P-2
P-3
P-4
P-5
P-6
P-7
RT 83-5
RT 83-6
RT 83-7
BROOKS ISLAND
ALL
NOTES
SAN FRANCISCO BAY
800
1,000
SHEET INDEX

PLAN



NOTES:

FOR NOTES SEE SHEET 1

LAN

4
1	2	3

SHEET INDEX

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

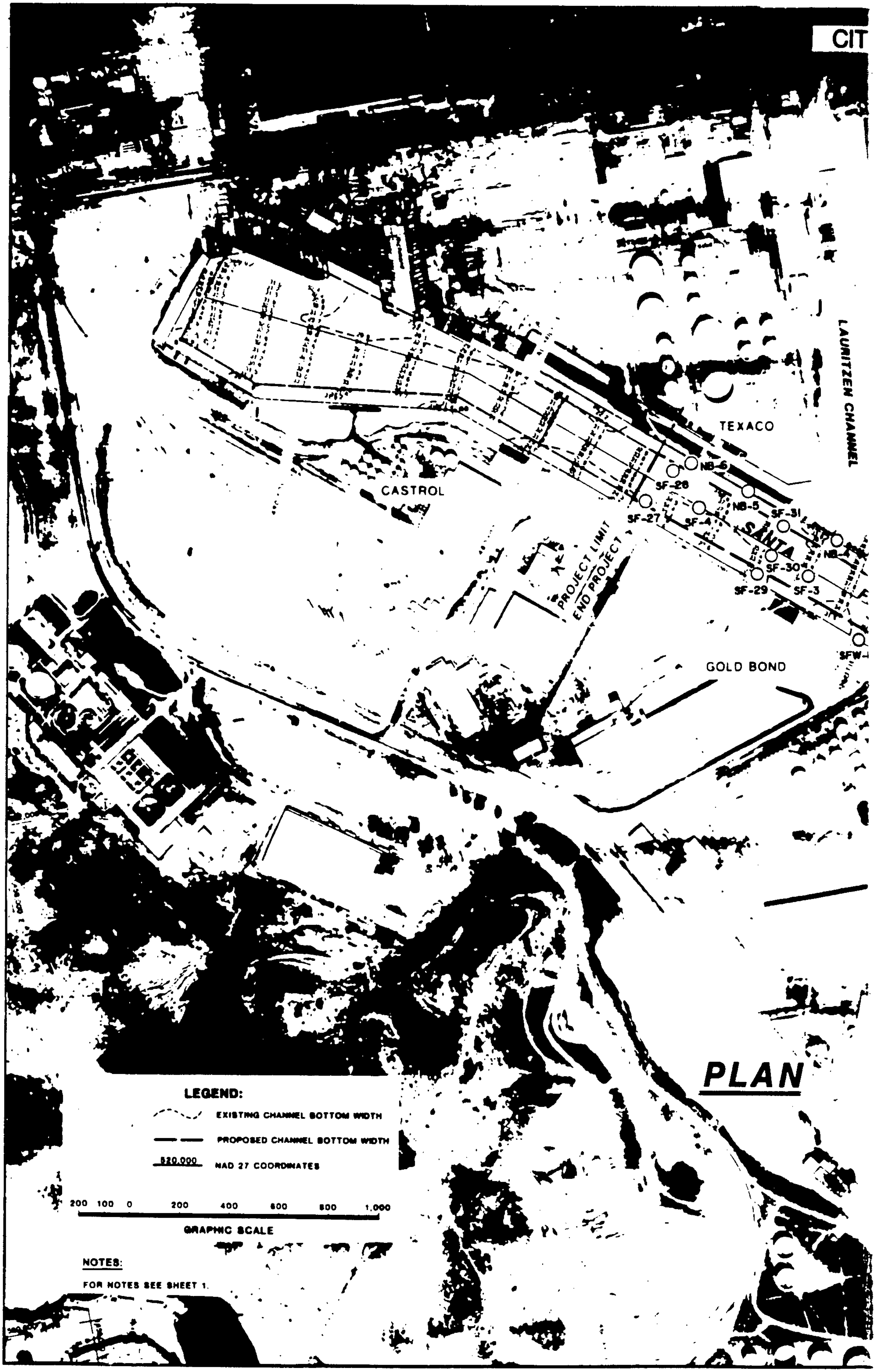
DRAWN BY: P H	CONTRA COSTA COUNTY — CALIFORNIA
TRACED BY	RICHMOND HARBOR (PHASE I)
CHECKED BY: K H	RECOMMENDED PLAN
SUBMITTED:	DEEPENING TO -38 FEET MLLW
APPROVAL RECOMMENDED	APPROVED: DATE

PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E., DISTRICT ENGINEER

SCALE 1" = 200'

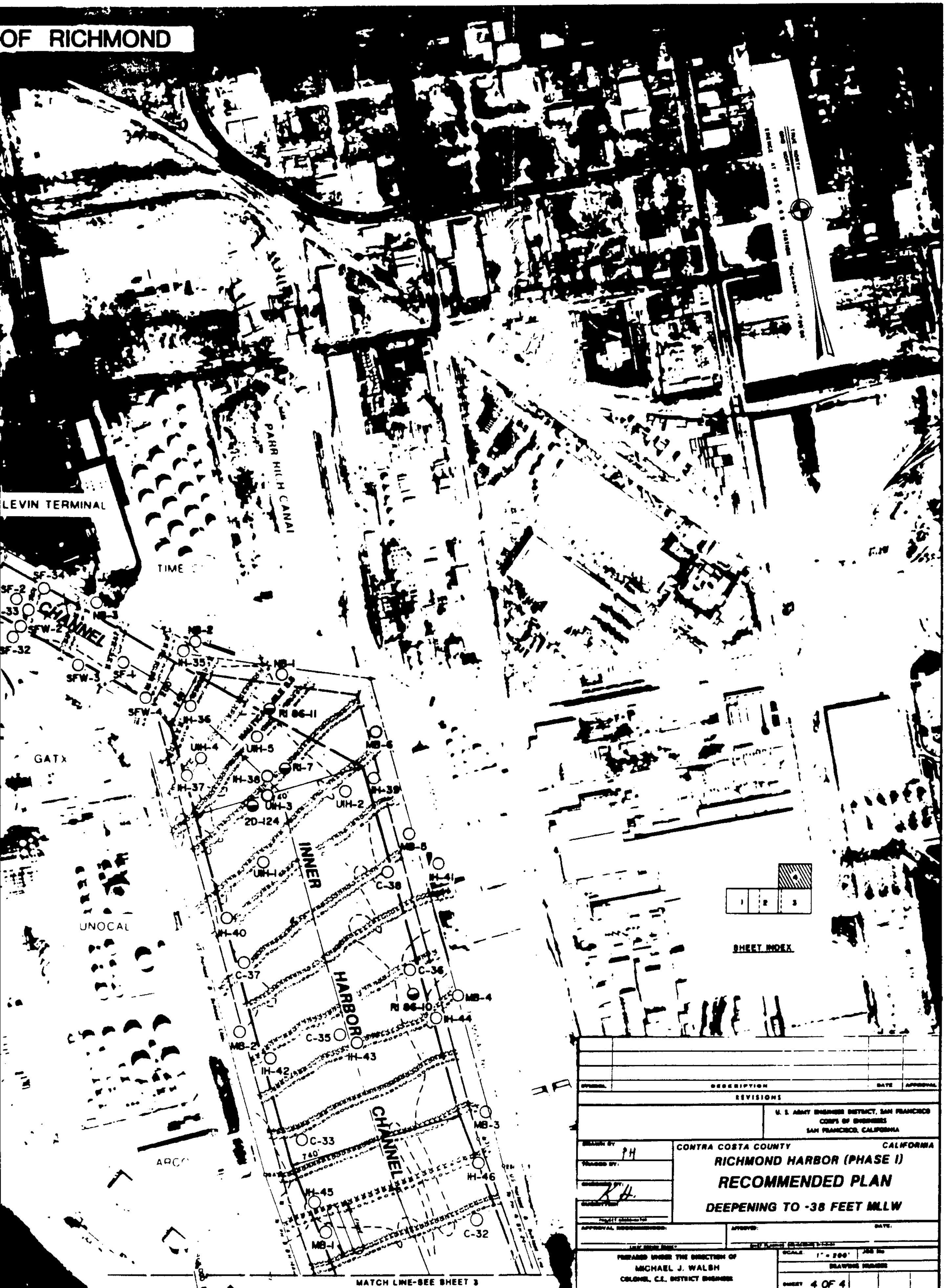
SHEET 3 OF 4

3

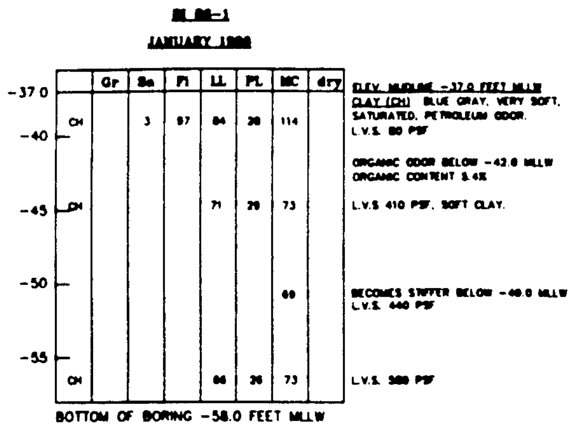

CIT
LAURITZEN CHANNEL
TEXACO
CASTROL
NB-6
SF-28
NB-5
SF-27
SF-4
SF-31
SANTA
SF-30
SF-29
SF-3
PROJECT LIMIT
END PROJECT
GOLD BOND
PLAN
LEGEND:
EXISTING CHANNEL BOTTOM WIDTH
PROPOSED CHANNEL BOTTOM WIDTH
520,000
NAD 27 COORDINATES
200 100 0 200 400 600 800 1,000
GRAPHIC SCALE
NOTES:
FOR NOTES SEE SHEET 1.

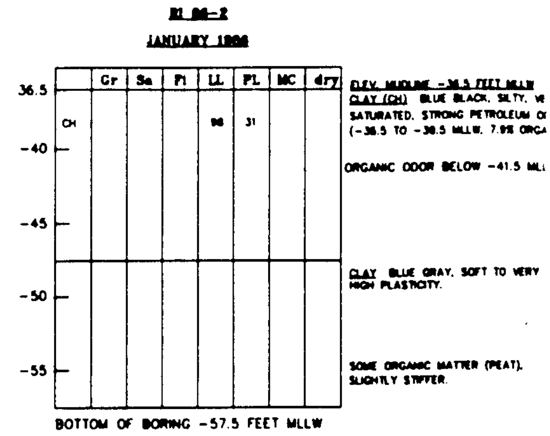
0

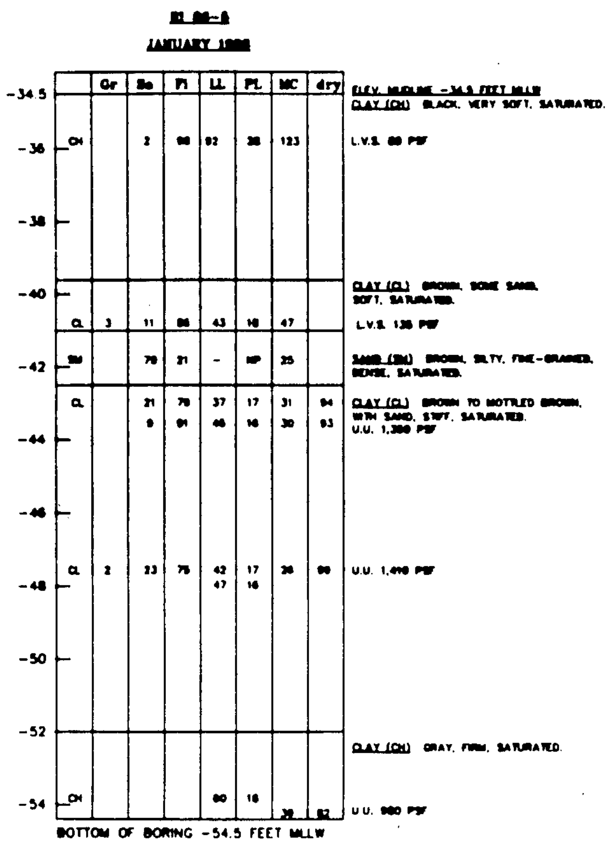

CITY OF RICHMOND
LAURITZEN CHANNEL
TEXACO
CASTROL
LEVIN TERMINAL
PARR HIGH CANAL
SANTA FE CHANNEL
PROJECT LIMIT
END PROJECT
GOLD BOND
GATX
UNOCAL
INNER HARBOR CHANNEL
PLAN
BOTTOM WIDTH
BOTTOM WIDTH
800
1,000
MATCH LINE-SEE SHEET

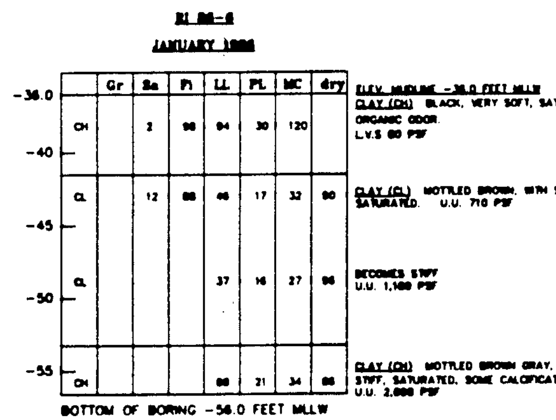

OF RICHMOND
LEVIN TERMINAL
PARR RICH CANAL
GATX
UNOCAL
ARCO
INNER
HARBOR
CHANNEL
CHANNEL
SF-34
SF-2
SF-32
SFW-2
SFW-3
SFW-4
MB-2
MB-1
MB-6
MB-5
MB-4
MB-3
IH-35
IH-36
IH-37
IH-38
IH-39
IH-40
IH-41
IH-42
IH-43
IH-44
IH-45
IH-46
UIH-1
UIH-2
UIH-3
UIH-4
UIH-5
RI-7
RI 86-11
RI 86-10
2D-124
C-32
C-33
C-35
C-36
C-37
C-38
SHEET INDEX
MATCH LINE-SEE SHEET 3
DESCRIPTION
DATE
REVISIONS
U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA
CONTRA COSTA COUNTY
CALIFORNIA
RICHMOND HARBOR (PHASE I)
RECOMMENDED PLAN
DEEPENING TO -38 FEET MLLW
PH
APPROVED:
DATE:
PREPARED UNDER THE DIRECTION OF
MICHAEL J. WALSH
COLONEL, C.E., DISTRICT ENGINEER
SCALE 1" = 200'
DRAWING NUMBER
SHEET 4 OF 4

APP. B PLATE 4









LEGEND:

SM SILTY SAND
CL CLAY (LOW PLASTICITY)
CH CLAY (HIGH PLASTICITY)
SC CLAYEY SAND
SP UNIFORM SAND
ML SILT (LOW PLASTICITY)
NP NON PLASTIC
Gr GRAVEL
Sa SAND
Fi FINES (PERCENT PASS NO. 200 SIEVE)
LL LIQUID LIMIT
PL PLASTIC LIMIT
MC MOISTURE CONTENT
dry DRY UNIT WEIGHT (POUNDS PER CUBIC FOOT)
UU UNCONSOLIDATED, UNDRAINED, TRIAXIAL SHEAR, STRENGTH (POUNDS PER SQUARE FOOT)
CU CONSOLIDATED, UNDRAINED, TRIAXIAL SHEAR, STRENGHT (POUNDS PER SQUARE FOOT)
LVS LABORATORY VANE SHEAR STRENGHT
UC UNCONFINED COMPRESSIVE STRENGTH

ULINE -37.0 FEET MLLW
) BLUE GRAY, VERY SOFT,
ED, PETROLEUM ODOR.
PSF

ODOR BELOW -42.0 MLLW
CONTENT 8.4%

PSF, SOFT CLAY.

STIFFER BELOW -40.0 MLLW
0 PSF

0 PSF

RI 86-2

JANUARY 1986

Elev. (ft MLLW)		Gr	Sa	Fi	LL	PL	MC	dry	Description
36.5	CH				98	31			ELEV. MUDLINE -36.5 FEET MLLW CLAY (CH) BLUE BLACK, SILTY, VERY SOFT, SATURATED, STRONG PETROLEUM ODOR, (-36.5 TO -38.5 MLLW, 7.9% ORGANICS)
-40									ORGANIC ODOR BELOW -41.5 MLLW
-45									
-50									CLAY BLUE GRAY, SOFT TO VERY SOFT, HIGH PLASTICITY.
-55									SOME ORGANIC MATTER (PEAT), SLIGHTLY STIFFER.

BOTTOM OF BORING -57.5 FEET MLLW

RI 86-3

JANUARY 1986

Elev. (ft MLLW)		Gr	Sa	Fi	LL	PL	MC	dry	Description
-40	CH	6	7	87	62	27	69		ELEV. MUDLINE -40 FEET MLLW CLAY (CH) BLUE GRAY, SILTY, SOFT SATURATED, SOME SHELL FRAGMENTS L.V.S 330 PSF
-45									
-50	CL		16	84	38	20	41		CLAY (CL) BLUE GRAY, WITH SAND, FIRM SATURATED. L.V.S. 980 PSF
-55	CL				33	21	34		ORGANIC 2.9% L.V.S. 460 PSF
-60	SM		85	15					SAND (SM) BLUE GRAY, SILTY, FINE-GRAINED, MEDIUM DENSE, SATURATED

BOTTOM OF BORING -61.0 FEET MLLW

ULINE -34.5 FEET MLLW
) BLACK, VERY SOFT, SATURATED.

PSF

L) BROWN, SOME SAND,
TURATED.
30 PSF

M) BROWN, SILTY, FINE-GRAINED,
SATURATED.

L) BROWN TO MOTTLED BROWN,
ND, STIFF, SATURATED.
00 PSF

0 PSF

RI 86-6

JANUARY 1986

Elev. (ft MLLW)		Gr	Sa	Fi	LL	PL	MC	dry	Description
-36.0	CH		2	98	94	30	120		ELEV. MUDLINE -36.0 FEET MLLW CLAY (CH) BLACK, VERY SOFT, SATURATED, ORGANIC ODOR. L.V.S 80 PSF
-40									
-45	CL		12	88	46	17	32	90	CLAY (CL) MOTTLED BROWN, WITH SAND, FIRM SATURATED. U.U. 710 PSF
-50	CL				37	16	27	98	BECOMES STIFF U.U. 1,100 PSF
-55	CH				66	21	34	88	CLAY (CH) MOTTLED BROWN GRAY, VERY STIFF, SATURATED, SOME CALCIFICATION U.U. 2,000 PSF

BOTTOM OF BORING -56.0 FEET MLLW

RI 86-7

JANUARY 1986

Elev. (ft MLLW)		Gr	Sa	Fi	LL	PL	MC	dry	Description
-39.8	CH		1	99	77	27	78		ELEV. MUDLINE -39.8 FEET MLLW CLAY (CH) BLUE GRAY, VERY SOFT TO SOFT, SATURATED, ORGANIC ODOR. L.V.S. 250 PSF
-45									SOME ORGANIC MATTER (PEAT) ORGANIC CONTENT 7.3%
-50	CH				98	32	94		L.V.S. 730 PSF
-55									
-60	CH				86	31	81		L.V.S. 810 PSF

BOTTOM OF BORING -60.8 FEET MLLW

M) GRAY, FIRM, SATURATED.

PSF

LEGEND:

- SM SILTY SAND
- CL CLAY (LOW PLASTICITY)
- CH CLAY (HIGH PLASTICITY)
- SC CLAYEY SAND
- SP UNIFORM SAND
- ML SILT (LOW PLASTICITY)
- NP NON PLASTIC
- Gr GRAVEL
- Sa SAND
- Fi FINES (PERCENT PASS NO. 200 SIEVE)
- LL LIQUID LIMIT
- PL PLASTIC LIMIT
- MC MOISTURE CONTENT
- dry DRY UNIT WEIGHT (POUNDS PER CUBIC FOOT)
- UU UNCONSOLIDATED, UNDRAINED, TRIAXIAL SHEAR, STRENGTH (POUNDS PER SQUARE FOOT)
- CU CONSOLIDATED, UNDRAINED, TRIAXIAL SHEAR, STRENGHT (POUNDS PER SQUARE FOOT)
- LVS LABORATORY VANE SHEAR STRENGHT
- UC UNCONFINED COMPRESSIVE STRENGTH

NOTES:

1. DEPTH IS REFERENCED TO MEAN LOWER LOW WATER, MLLW.
2. DESCRIPTION BASED ON FIELD OBSERVATION.
3. SYMBOL DESCRIPTIONS AND NUMBERS BASED ON LAB TESTS.
4. 1986 BORINGS ACCOMPLISHED USING A FAILING 1500 ROTARY DRILL TAKING 3" DIAMETER STEEL PUSH TUBE SAMPLES. PERFORMED SAMPLING OF 3 FEET MAXIMUM PER SAMPLE. A 3" DIAMETER MODIFIED CALIFORNIA SAMPLER DRIVEN IN DENSE TO STIFF MATERIAL.
5. BORINGS RI-1 THROUGH RI-7 (SEPTEMBER 1985) ACCOMPLISHED USING 3" DIAMETER PISTON DROP CORE SAMPLER LINED WITH 2.62" O.D. PLATIC LINER.
6. BORINGS TAKEN PARALLEL TO THE RICHMOND TRAINING WALL (RT 83-1 THROUGH RT 83-7) ACCOMPLISHED USING A FAILING 1500 ROTARY DRILL TAKING 3" DIAMETER STEEL PUSH TUBE SAMPLES ON APPROXIMATE 20-FOOT INTERVALS OF DEPTH. THE REST OF EACH BORING WAS CONTINUOUSLY SAMPLED USING A SPLIT SPOON SAMPLE AND SAMPLES LOGGED IN THE FIELD.
7. BORINGS TAKEN FROM 1973 THROUGH 1981 WERE ACCOMPLISHED USING 2" TO 2.18" I.D. PLASTIC LINERS INSIDE OF STEEL SAMPLING TUBES OR OTHER TYPES OF STEEL SAMPLERS. CONTINUOUS SAMPLING WAS PERFORMED.

RI 86-3

JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-40	CH	6	7	87	62	27	69		ELEV. MUDLINE -40 FEET MLLW CLAY (CH) BLUE GRAY, SILTY, SOFT SATURATED, SOME SHELL FRAGMENTS L.V.S 320 PSF
-45									
	CL		16	84	38	20	41		CLAY (CL) BLUE GRAY, WITH SAND, FIRM SATURATED. L.V.S. 580 PSF
-50									
-55	CL				33	21	34		ORGANIC 2.9% L.V.S. 460 PSF
-60	SM		85	15					SAND (SM) BLUE GRAY, SILTY, FINE-GRAINED, MEDIUM DENSE, SATURATED

BOTTOM OF BORING -61.0 FEET MLLW

RI 86-4

JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
36.5									ELEV. MUDLINE -36.5 FEET MLLW
-40	CH		15	85	51	22	58		CLAY (CH) BLUE GRAY, WITH SAND, SOFT, SATURATED, ORGANIC ODOR. L.V.S. 305 PSF
-45	CH		1	99	50	22	41		CLAY (CH) BLUE GRAY, STIFF TO VERY STIFF, SATURATED. L.V.S 2,120 PSF
-50	CH		3	97	67	22	41	80	CLAY (CH) MOTTLED BROWN, STIFF, SATURATED U.U. 1,930 PSF
-55	CH			100	56	19	32	89	CLAY (CH) GREEN BROWN, STIFF, SATURATED. U.U. 1,980 PSF

BOTTOM OF BORING -57.5 FEET MLLW

RI 86-7

JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-39.8	CH		1	99	77	27	78		ELEV. MUDLINE -39.8 FEET MLLW CLAY (CH) BLUE GRAY, VERY SOFT TO SOFT, SATURATED, ORGANIC ODOR. L.V.S. 256 PSF
-45									SOME ORGANIC MATTER (PEAT) ORGANIC CONTENT 7.3%
	CH				99	32	94		L.V.S. 730 PSF
-50									
-55									
-60	CH				86	31	81		L.V.S. 810 PSF

BOTTOM OF BORING -60.8 FEET MLLW

RI 86-8

JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-5.0	CH		3	97	73	25	106		ELEV. MUDLINE -5.0 FEET MLLW CLAY (CH) BLUE GRAY, VERY SOFT, SATURATED OCCASIONAL SHELLS, ORGANIC ODOR. L.V.S. 80 PSF
-10	CH		1	99	94	29	63		ORGANIC ODOR L.V.S. 300 PSF
-15	CH		1	99	90	26	66		L.V.S. 305 PSF
-20	CH		1	99	64	28	72		CONSISTENCY IS SOFT L.V.S. 400 PSF
-25	CH		1	99	91	23	56		L.V.S. 300 PSF
-30									
-35	SC		53	47	39	18	33		SAND (SC) BLUE GRAY, CLAYEY, FINE TO MEDIUM-GRAINED, SOFT TO LOOSE, SATURATED. L.V.S. 370 PSF
-40	SM		63	37	-	NP	25		SAND (SM) BLUE GRAY, SILTY, FINE TO MEDIUM-GRAINED, MEDIUM DENSE SATURATED, SOME SHELL FRAGMENTS
	SC	33	44	23	48	21	27		SAND (SC) GRAY BLUE, CLAYEY WITH FINE GRAVEL, DENSE, SATURATED
-45	SM	3	82	15	-	NP	15	119	SAND (SM) GRAY BLUE, SILTY WITH A LITTLE FINE GRAVEL, DENSE, SATURATED.
-50	CH				64	24	98	63	U.U. 330 PSF
-55	SC	24	52	24	36	30	26		SAND (SC) BLUE CLAYEY WITH FINE GRAVEL, COARS TO MEDIUM-GRAINED SAND, VERY DENSE. GRAVEL IS SUBANGULAR TO ROUNDED.

BOTTOM OF BORING -55.0 FEET MLLW

ES:

DEPTH IS REFERENCED TO MEAN LOWER LOW WATER, MLLW.

DESCRIPTION BASED ON FIELD OBSERVATION.

SYMBOL DESCRIPTIONS AND NUMBERS BASED ON LAB TESTS.

1986 BORINGS ACCOMPLISHED USING A FAILING 1500 ROTARY DRILL TAKING 3" DIAMETER STEEL PUSH TUBE SAMPLES PERFORMED SAMPLING OF 3 FEET MAXIMUM PER SAMPLE A 3" DIAMETER MODIFIED CALIFORNIA SAMPLER DRIVEN IN DENSE TO STIFF MATERIAL.

BORINGS RI-1 THROUGH RI-7 (SEPTEMBER 1985) ACCOMPLISHED USING 3" DIAMETER PISTON DROP CORE SAMPLER LINED WITH 2.62" O.D. PLATIC LINER.

BORINGS TAKEN PARALLEL TO THE RICHMOND TRAINING WALL (RT 83-1 THROUGH RT 83-7) ACCOMPLISHED USING A FAILING 1500 ROTARY DRILL TAKING 3" DIAMETER STEEL PUSH TUBE SAMPLES ON APPROXIMATE 20-FOOT INTERVALS OF DEPTH. THE REST OF EACH BORING WAS CONTINUOUSLY SAMPLED USING A SPLIT SPOON SAMPLE AND SAMPLES LOGGED IN THE FIELD.

BORINGS TAKEN FROM 1973 THROUGH 1981 WERE ACCOMPLISHED USING 2" TO 2.18" I.D. PLASTIC LINERS INSIDE OF STEEL SAMPLING TUBES OR OTHER TYPES OF STEEL SAMPLERS. CONTINUOUS SAMPLING WAS PERFORMED

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DESIGNED BY: PH

DRAWN BY:

CHECKED BY: K //

CONTRA COSTA COUNTY CALIFORNIA

RICHMOND INNER HARBOR
LOGS OF EXPLORATION BORINGS

PREPARED UNDER THE DIRECTION OF
[illegible]
COLONEL, C.E., DISTRICT ENGINEER

SHEET 1 | 9 | 5 | 7

APP. B PLATE 5

3

RI 86-9
JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	
-36.0									ELEV. MUDLINE -36.0 FEET MLLW
	CH		4	96	95	30	93		CLAY (CH) BLUE BLACK VERY SOFT, SATURATED, ORGANIC ODOR L.V.S. 70 PSF
-40									
	SC		74	26	40	15	26		SAND (SC) BROWN, CLAYEY, FINE-GRAINED MEDIUM DENSE, SATURATED, OCCASIONAL FINE GRAVEL.
-45									
	CL				46	18	26	98	CLAY (CL-CH) BLUE GRAY, VERY STIFF, SATURATED, SOME CALCIFICATION U.U. 2,500 PSF
-50									
-55	CH				58	21	28	94	U.U. 2,700 PSF

BOTTOM OF BORING -56.0 FEET MLLW

RI 86-10
JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	
-38.0									ELEV. MUDLINE -38.0 FEET MLLW CLAY BLUE GRAY, SILTY, SOFT, HIGH PLASTICITY, SLIGHT PETROL
-40									
									CLAY (CL) GRAY, SOME SAND, S TO VERY STIFF, SATURATED
-45	CL		16	84	38	18	27	98	U.U. 1,920 PSF
	CL				38	18	26	97	U.U. 2,820 PSF
-50									
	CL				40	19	22	102	U.U. 3,540 PSF
-55									
	CL				42	20	28	95	U.U. 3,310 PSF

BOTTOM OF BORING -58.0 FEET MLLW

RO 86-8
FEBRUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	
-36.5									ELEV. MUDLINE -36.5 FEET MLLW
	CH	-	8	91	58	28	70	-	CLAY (CH) GRAY, SATURATED, VERY SOFT L.V.S. 170 PSF
-40	CH	14	28	68	54	24	70	-	SANDY CLAY (CH) GRAY, SATURATED, SOFT, V.S. 330 PSF
-45	CH	-	3	97	52	27	75	-	CLAY (CH) GRAY, SATURATED, SOFT L.V.S. 200 PSF
-50	CL	-	27	73	40	25	61	-	SANDY CLAY (CL) GRAY, SATURATED, VERY SOFT, L.V.S. 166 PSF
-55							43	78	CLAY (CH) GRAY, SATURATED, SOFT TO FIRM, U.U. 400 PSF
-60	CH				63	18	43	77	U.U. 560 PSF
-65									
-69							55	67	U.U. 330 PSF

BOTTOM OF BORING -69.0 FEET MLLW

RI-1
SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	
-22.8									ELEV. MUDLINE -22.8 FEET MLLW CLAY GRAY, VERY SOFT TO SOFT HIGH PLASTICITY
-24									
-26									
-28									
-30									

BOTTOM OF BORING -31.8 FEET MLLW

RI-4
SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	
-32.2									ELEV. MUDLINE -32.2 FEET MLLW CLAY (CL) TAN, SANDY, STIFF, SATURATED.
-34	CL		36	64	47	16	30	91	U.U. 1,000 PSF
	CL		47	53	36	16	24		L.V.S. 995 PSF
-36									CLAY (CH) GRAY, SOFT TO VERY SOFT, SATURATED
-38	CH		4	96	90	31	107		L.V.S. 60 PSF
-40									VERY SOFT, LOST CORE -39.2 TO -42.2 FEET MLLW
-42									

BOTTOM OF BORING -42.2 FEET MLLW

RI-5
SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	
-28.7									ELEV. MUDLINE -28.7 FEET MLLW CLAY (CH) GRAY, SILTY, SOFT, SATURATED
-30									
-32	CH		5	95	70	23	70		L.V.S. 330 PSF
-34									
-36	CH		2	98	89	27	89		L.V.S. 340 PSF

BOTTOM OF BORING -36.7 FEET MLLW

1

FEET MLLW
CK VERY SOFT,
ODOR

LAYEY, FINE-GRAINED
ATED, OCCASIONAL

GRAY, VERY STIFF,
CIFICATION

FEET MLLW
TURATED, VERY SOFT

AY, SATURATED, SOFT,

TURATED, SOFT.

AY, SATURATED, VERY SOFT.

TURATED, SOFT TO FIRM.

FEET MLLW
DY, STIFF.

FT TO VERY SOFT.

E -39.2 TO

BI 86-10

JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-38.0									ELEV. MUDLINE -38.0 FEET MLLW CLAY BLUE GRAY, SILTY, SOFT, SATURATED, HIGH PLASTICITY, SLIGHT PETROLEUM ODOR
-40									
									CLAY (CL) GRAY, SOME SAND, STIFF TO VERY STIFF, SATURATED
-45	CL		16	84	36	18	27	98	U.U. 1,820 PSF
	CL				38	18	26	97	U.U. 2,820 PSF
-50									
	CL				40	19	22	102	U.U. 3,540 PSF
-55									
	CL				47	20	28	95	U.U.3,310 PSF

BOTTOM OF BORING -58.0 FEET MLLW

BI 86-11

JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-35.9									ELEV. MUDLINE -35.9 FEET MLLW CLAY (CL-CH) BLUE BLACK, SILTY, FIRM, SATURATED, ORGANIC ODOR. U.U. 950 PSF MAY RANGE FORM HIGH TO LOW PLASTICITY
	CL		7	93	49	18	31	89	
-40									SILT BLUE GRAY, SANDY, VERY DENSE, SATURATED, LOW PLASTICITY.
	CL		4	96	40	19	30	93	CLAY (CL-CH) BLUE GRAY, SILTY, STIFF TO HARD, SATURATED. U.U. 1,420 PSF SOME CALCIFICATION.
-45	CH				54	18	24	101	U.U. 4,380 PSF
									SAND GREEN GRAY, CLAYEY, FINE-GRAINED DENSE, SATURATED.
-50									
									CLAY BLUE GRAY, SILTY, STIFF, SATURATED, MODERATE TO VERY PLASTIC, SOME CALCIFICATION.
-55	CL				46	20	28	93	U.U. 1,910 PSF

BOTTOM OF BORING -55.9 FEET MLLW

BI-1

SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-22.8									ELEV. MUDLINE -22.8 FEET MLLW CLAY GRAY, VERY SOFT TO SOFT, SATURATED, HIGH PLASTICITY
-24									
-26									
-28									
-30									

BOTTOM OF BORING -31.8 FEET MLLW

BI-2

SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-29.0									ELEV. MUDLINE -29.0 FEET MLLW CLAY (CH) GRAY, VERY SOFT TO SOFT, SATURATED.
-30									
	CH		1	99	96	32	99		L.V.S. 108 PSF
-32									
-34									
-36	CH	1	10	89	81	24	64		L.V.S. 208 PSF
-38									

BOTTOM OF BORING -38.5 FEET MLLW

BI-5

SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-28.7									ELEV. MUDLINE -28.7 FEET MLLW CLAY (CH) GRAY, SILTY, SOFT, SATURATED
-30									
-32	CH		5	95	70	23	70		L.V.S. 330 PSF
-34									
	CH		2	98	89	27	89		L.V.S. 340 PSF
-36									

BOTTOM OF BORING -36.7 FEET MLLW

BI-6

SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-14.3									ELEV. MUDLINE -14.3 FEET MLLW CLAY (CH) GRAY, SOFT, SATURATED, SHELLS AT TOP OF CORE.
-16	CH		1	99	58	25	58		L.V.S. 235 PSF
-18									
-20									
	CH		9	91	83	29	97		L.V.S. 140 PSF
-22									

BOTTOM OF BORING -22.8 FEET MLLW

BI-7

SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-35.4									ELEV. MUDLINE -35.4 FEET MLLW CLAY (CH) GRAY, SOME SAND, SOFT SATURATED
-36									
	CH		10	90	63	22	60		L.V.S. 258 PSF
-38									CLAY (CH) GRAY, SOME SAND, STIFF SATURATED VERY STIFF AT -39.4
	CH		11	89	55	19	29	92	U.U. 1,090 PSF

BOTTOM OF BORING -39.4 FEET MLLW

RI 86-11
JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-35.9									ELEV. MUDLINE -35.9 FEET MLLW
	CL		7	93	49	18	31	89	CLAY (CL-CH) BLUE BLACK, SILTY, FIRM, SATURATED, ORGANIC ODOR. U.U 950 PSF MAY RANGE FORM HIGH TO LOW PLASTICITY
-40									SILT BLUE GRAY, SANDY, VERY DENSE, SATURATED, LOW PLASTICITY
	CL		4	96	40	19	30	93	CLAY (CL-CH) BLUE GRAY, SILTY, STIFF TO HARD, SATURATED. U.U. 1,420 PSF
-45	CH				54	16	24	101	SOME CALCIFICATION. U.U. 4,380 PSF
-50									SAND GREEN GRAY, CLAYEY, FINE-GRAINED DENSE, SATURATED
-55	CL				44	20	28	93	CLAY BLUE GRAY, SILTY, STIFF, SATURATED. MODERATE TO VERY PLASTIC, SOME CALCIFICATION. U.U. 1,910 PSF

BOTTOM OF BORING -55.9 FEET MLLW

RI 86-12
JANUARY 1986

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-5.0									ELEV. MUDLINE -5.0 FEET MLLW
	CH	2	22	76	52	24	55		CLAY (CH) BLUE GRAY, WITH SAND, VERY SOFT, SATURATED, SHELL FRAGMENTS. L.V.S 170 PSF. ABUNDANT SHELLS AT -8 MLLW.
-10	CL		4	96	39	25	47		CLAY (CL) BLUE GRAY, SILTY, SOFT, SATURATED, A FEW SHELLS. L.V.S. 336 PSF
-15	CL		1	99	48	25	47	74	L.V.S. 140 PSF, VERY SOFT.
-20	CH		1	99	61	25	62		CLAY (CH) BLUE GRAY, VERY SOFT TO FIRM, WET. L.V.S. 240 PSF
-25	CH		2	98	55	24	58		SOFT, L.V.S. 400 PSF
	CH		7	93	50	22	46		FIRM, L.V.S. 620 PSF
-30									SAND (SM) BLUE GRAY, SILTY, MEDIUM DENSE, SATURATED.
-35	SM		70	30	-	NP			
	CH		7	93	80	25	54	66	CLAY (CH) BLUE GRAY, SOFT TO FIRM, WET. U.U. 400 PSF
-40									
-45	CH		7	93	73	26	81	62	U.U. 580 PSF

BOTTOM OF BORING -45.0 FEET MLLW

RI-2
SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-29.0									ELEV. MUDLINE -29.0 FEET MLLW CLAY (CH) GRAY, VERY SOFT TO SOFT, SATURATED
-30	CH		1	99	96	32	99		L.V.S. 100 PSF
-32									
-34									
-36	CH	1	10	89	61	24	64		L.V.S. 290 PSF
-38									

BOTTOM OF BORING -38.5 FEET MLLW

RI-3
SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-29.6									ELEV. MUDLINE -29.6 MLLW CLAY GRAY, SOFT, SATURATED, HIGH PLASTICITY.
-30									
-32									
-34									
-36									
-38									
-40									
-42									

BOTTOM OF BORING -42.1 FEET MLLW

RI-6
SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-14.3									ELEV. MUDLINE -14.3 FEET MLLW CLAY (CH) GRAY, SOFT, SATURATED. SHELLS AT TOP OF CORE.
-16	CH		1	99	58	25	56		L.V.S. 235 PSF
-18									
-20	CH		9	91	83	29	97		L.V.S. 140 PSF
-22									

BOTTOM OF BORING -22.8 FEET MLLW

RI-7
SEPTEMBER 1985

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-35.4									ELEV. MUDLINE -35.4 FEET MLLW CLAY (CH) GRAY, SOME SAND, SOFT SATURATED
-36	CH		10	90	63	22	60		L.V.S 258 PSF
-38									CLAY (CH) GRAY, SOME SAND, STIFF SATURATED VERY STIFF AT -39.4
	CH		11	89	55	19	29	92	U.U. 1,090 PSF

BOTTOM OF BORING -39.4 FEET MLLW

SYMBOL	DESCRIPTION	DATE	APPROVAL
	REVISIONS		

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

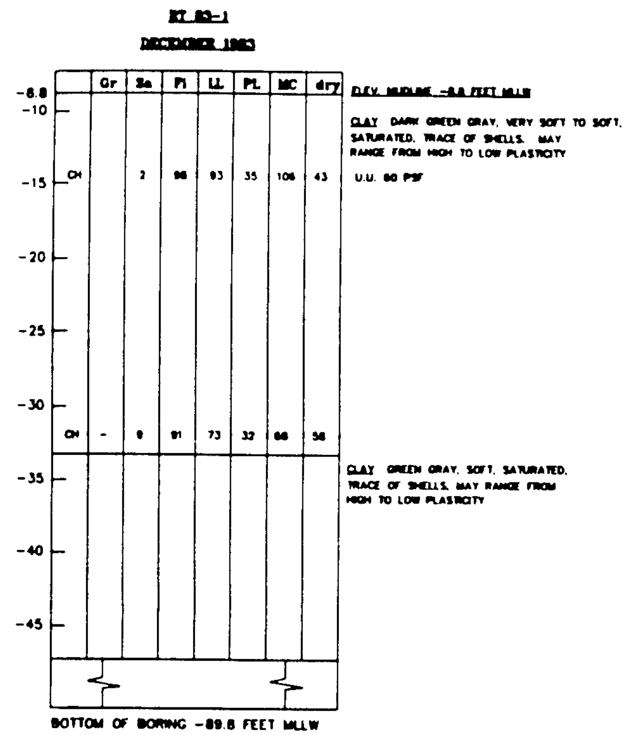
DESIGNED BY: PH
CONTRA COSTA COUNTY CALIFORNIA

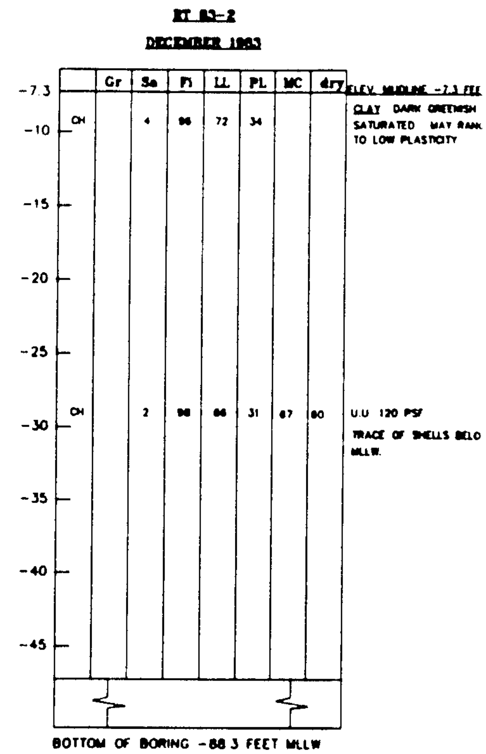
RICHMOND INNER HARBOR
LOGS OF EXPLORATION BORINGS

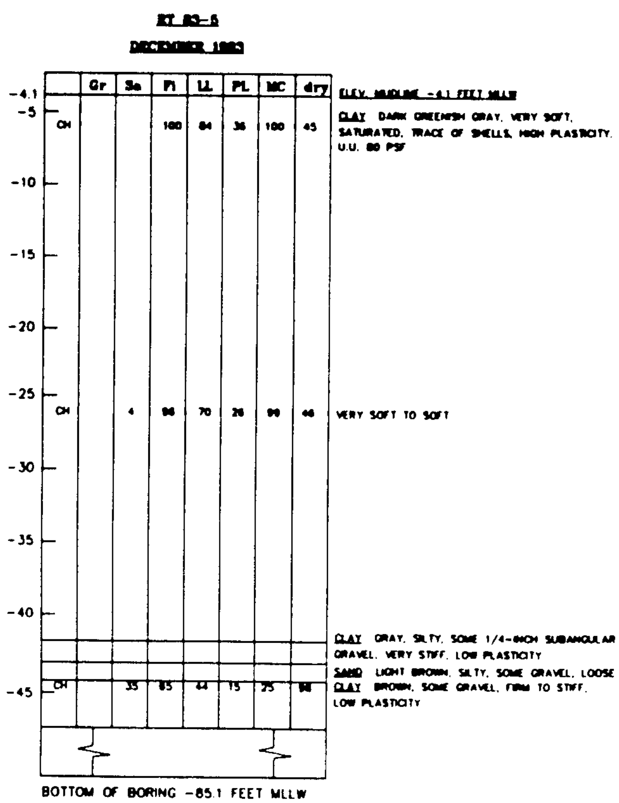
SHEET 2 9 5 7

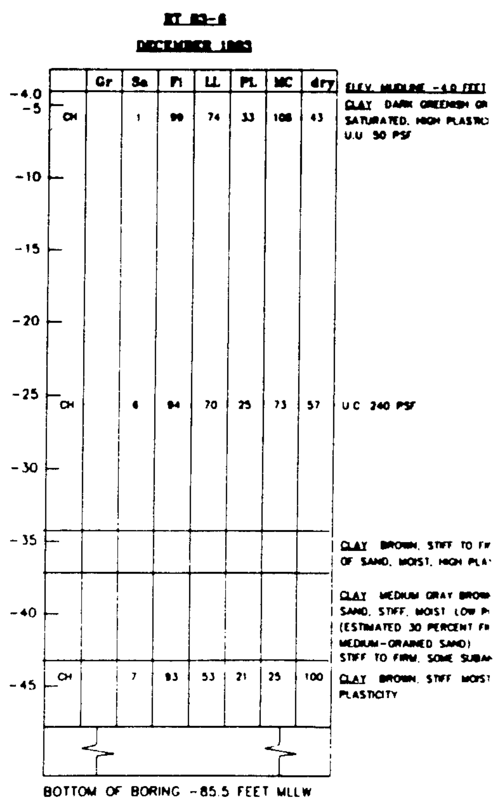
(3)

APP. B PLATE 6


DECEMBER 1983
Gr
Sa
Fi
LL
PL
MC
dry
CLAY DARK GREEN GRAY, VERY SOFT TO SOFT, SATURATED, TRACE OF SHELLS. MAY RANGE FROM HIGH TO LOW PLASTICITY
CH
U.U. 80 PSF
CLAY GREEN GRAY, SOFT, SATURATED, TRACE OF SHELLS, MAY RANGE FROM HIGH TO LOW PLASTICITY
BOTTOM OF BORING -89.8 FEET MLLW

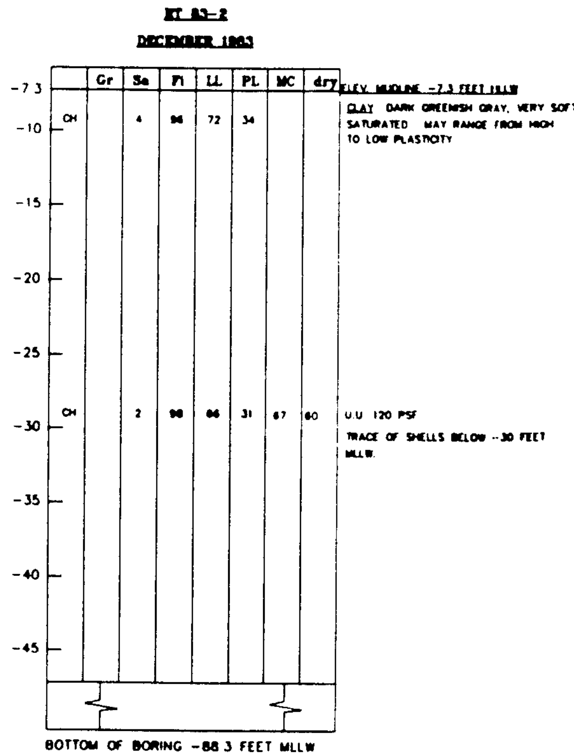

DECEMBER 1983
Gr
Sa
Fi
LL
PL
MC
dry
CLAY DARK GREENISH
SATURATED MAY RANG
TO LOW PLASTICITY
CH
U.U 120 PSF
TRACE OF SHELLS BELO
MLLW.
BOTTOM OF BORING -88.3 FEET MLLW

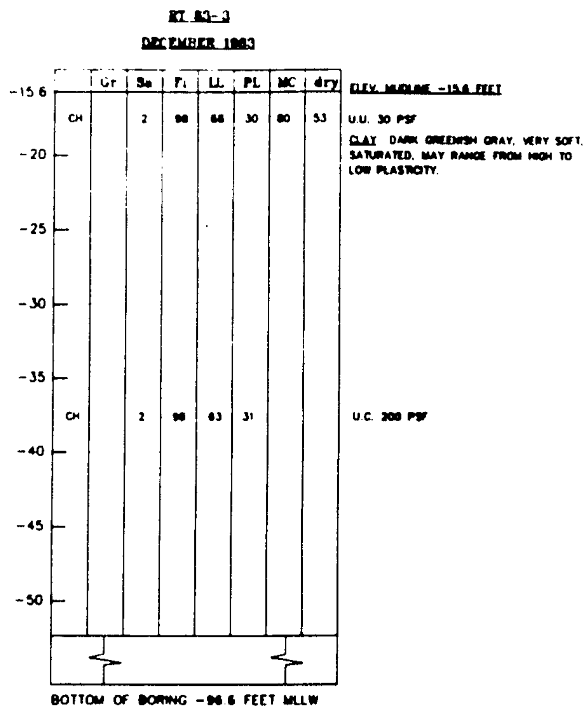

DECEMBER 1983
Gr
Sa
Fi
LL
PL
MC
dry
CLAY DARK GREENISH GRAY, VERY SOFT, SATURATED, TRACE OF SHELLS, HIGH PLASTICITY. U.U. 80 PSF
CH
VERY SOFT TO SOFT
CLAY GRAY, SILTY, SOME 1/4-INCH SUBANGULAR GRAVEL, VERY STIFF, LOW PLASTICITY
SAND LIGHT BROWN, SILTY, SOME GRAVEL, LOOSE
CLAY BROWN, SOME GRAVEL, FIRM TO STIFF, LOW PLASTICITY
BOTTOM OF BORING -85.1 FEET MLLW


DECEMBER 1983
Gr
Sa
Fi
LL
PL
MC
dry
CLAY DARK GREENISH GR
SATURATED, HIGH PLASTIC
U.U 50 PSF
CH
U.C 240 PSF
CLAY BROWN, STIFF TO FI
OF SAND, MOIST, HIGH PLA
CLAY MEDIUM GRAY BROW
SAND, STIFF, MOIST LOW P
(ESTIMATED 30 PERCENT FI
MEDIUM-GRAINED SAND)
STIFF TO FIRM, SOME SUBA
CLAY BROWN, STIFF MOIST
PLASTICITY
BOTTOM OF BORING -85.5 FEET MLLW

-8.8 FEET MLLW
EEN GRAY, VERY SOFT TO SOFT,
ACE OF SHELLS. MAY
GH TO LOW PLASTICITY

RAY, SOFT, SATURATED,
LS. MAY RANGE FROM
LASTICITY

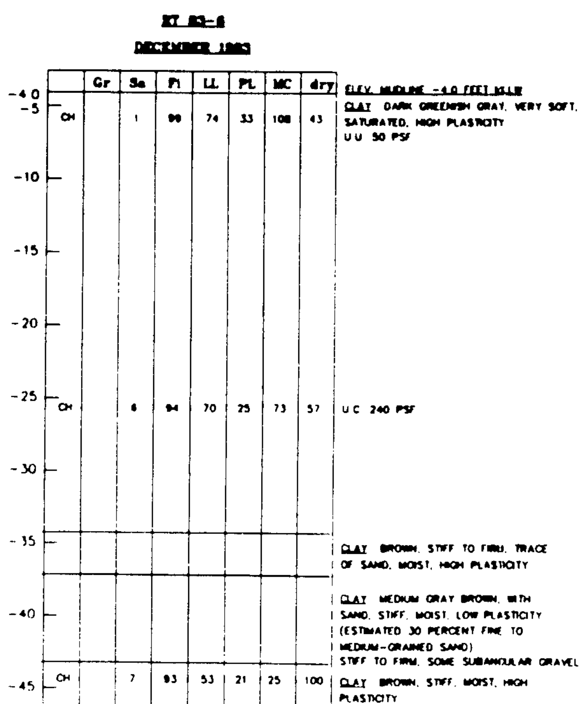


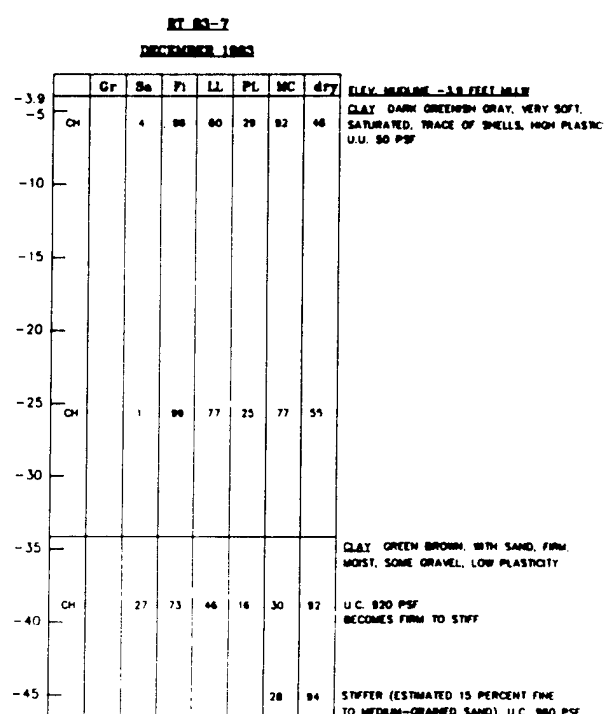


4.1 FEET MLLW
ENISH GRAY, VERY SOFT,
E OF SHELLS, HIGH PLASTICITY.

FT.

Y, SOME 1/4-INCH SUBANGULAR
FF, LOW PLASTICITY
WN, SILTY, SOME GRAVEL, LOOSE
ME GRAVEL, FIRM TO STIFF





RT 83-3
DECEMBER 1983

ELEV. MUDLINE -15.6 FEET

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-15.6 to -20	CH		2	98	68	30	80	53	U.U. 30 PSF CLAY DARK GREENISH GRAY, VERY SOFT, SATURATED, MAY RANGE FROM HIGH TO LOW PLASTICITY
-35 to -40	CH		2	98	83	31			U.C. 200 PSF

Elevation scale: -15.6, -20, -25, -30, -35, -40, -45, -50

BOTTOM OF BORING -96.6 FEET MLLW

RT 83-4
DECEMBER 1983

ELEV. MUDLINE -3.5 FEET MLLW

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-5	CH		2	98	81	34	84	52	CLAY DARK GREENISH GRAY, VERY SOFT, SATURATED, HIGH PLASTICITY, TRACE OF SHELL. U.U. 80 PSF
-25	CH				71	33	77	55	U.C. 100 PSF
-40 to -45	CL		17	83	42	15	24	99	CLAY BLUE GRAY, STIFF, TRACE OF SAND, LOW PLASTICITY. (INCREASE OF SAND CONTENT) C.U. 3,840 PSF

Elevation scale: -3.5, -5, -10, -15, -20, -25, -30, -35, -40, -45

BOTTOM OF BORING -84.5 FEET MLLW

RT 83-7
DECEMBER 1983

ELEV. MUDLINE -3.9 FEET MLLW

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-5	CH		4	96	80	29	92	46	CLAY DARK GREENISH GRAY, VERY SOFT, SATURATED, TRACE OF SHELLS, HIGH PLASTICITY. U.U. 50 PSF
-25	CH		1	99	77	25	77	55	
-35									CLAY GREEN BROWN WITH SAND, FIRM, MOIST, SOME GRAVEL, LOW PLASTICITY
-40	CH		27	73	46	16	30	92	U.C. 820 PSF BECOMES FIRM TO STIFF
-45							28	94	STIFFER (ESTIMATED 15 PERCENT FINE TO MEDIUM-GRAINED SAND), U.C. 960 PSF

Elevation scale: -3.9, -5, -10, -15, -20, -25, -30, -35, -40, -45

BOTTOM OF BORING -83.4 FEET MLLW

2D-204
DECEMBER 1983

ELEV. MUDLINE -34 FEET MLLW

Elev.		Gr	Sa	Fi	LL	PL	MC	dry	Description
-34 to -36									CLAY GRAY, SILTY, VERY SOFT, WET, HIGH PLASTICITY

BOTTOM OF BORING -37 FEET MLLW

SYMBOL	DESCRIPTION	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DESIGNED BY: PH
TRACED BY:
CHECKED BY: [illegible]

CONTRA COSTA COUNTY — CALIFORNIA

RICHMOND INNER HARBOR
LOGS OF EXPLORATION BORINGS

APPROVAL RECOMMENDED:
APPROVED: DATE:

PREPARED UNDER THE DIRECTION OF
GALEN YANAGIHARA
COLONEL, C.E. DISTRICT ENGINEER

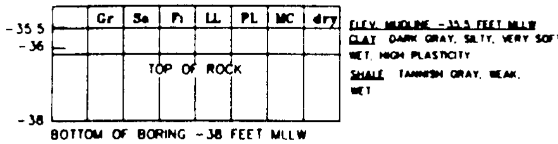
SCALE: | SPEC No.
DRAWING NUMBER
SHEET 3 | 9 | 5 | 7

APP. B PLATE 7

3

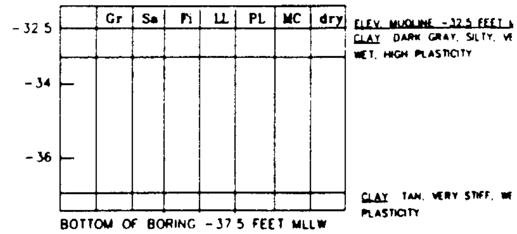
2D-130

AUGUST 1976



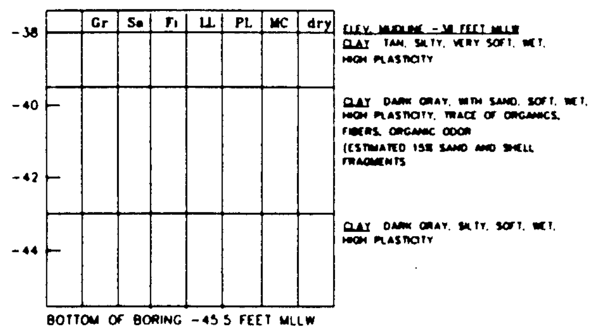
2D-139

AUGUST 1976



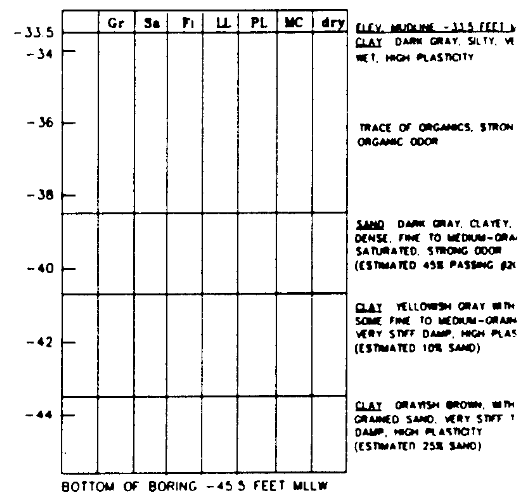
2D-113

MAY 1974



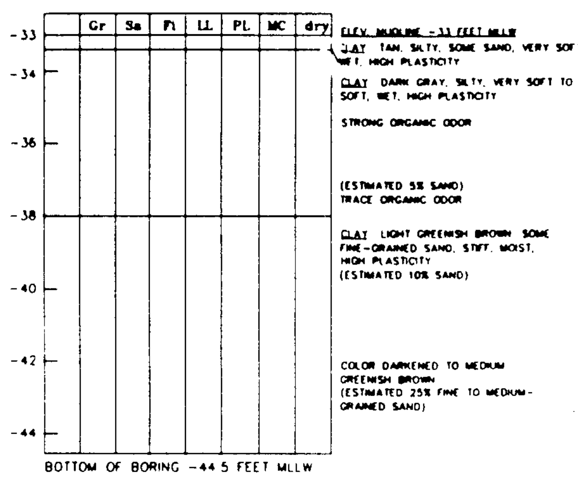
2D-118

MAY 1974



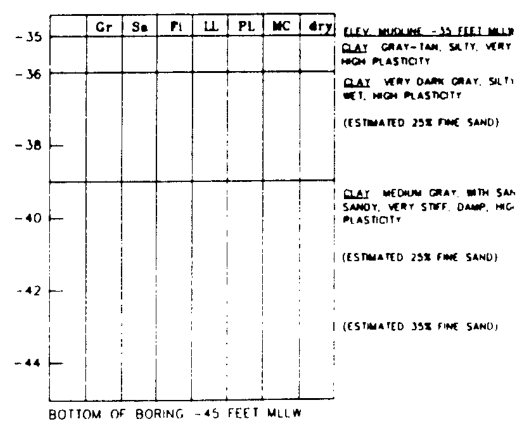
2D-117

MAY 1974



2D-123

MAY 1974



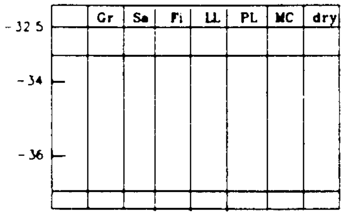
UDLINE -35.5 FEET MLLW
ARK GRAY, SILTY, VERY SOFT,
H PLASTICITY
TANNISH GRAY, WEAK.

UDLINE -38 FEET MLLW
TAN, SILTY, VERY SOFT, WET,
ASTICITY
DARK GRAY, WITH SAND, SOFT, WET,
ASTICITY, TRACE OF ORGANICS,
ORGANIC ODOR
TED 15% SAND AND SHELL
NTS
DARK GRAY, SILTY, SOFT, WET,
ASTICITY

UDLINE -33 FEET MLLW
AN, SILTY, SOME SAND, VERY SOFT,
H PLASTICITY
DARK GRAY, SILTY, VERY SOFT TO
ET, HIGH PLASTICITY
ORGANIC ODOR
TED 5% SAND)
RGANIC ODOR
IGHT GREENISH BROWN SOME
AINED SAND, STIFF, MOIST,
ASTICITY
TED 10% SAND)
DARKENED TO MEDIUM
H BROWN
TED 25% FINE TO MEDIUM-
SAND)

2D-139

AUGUST 1976



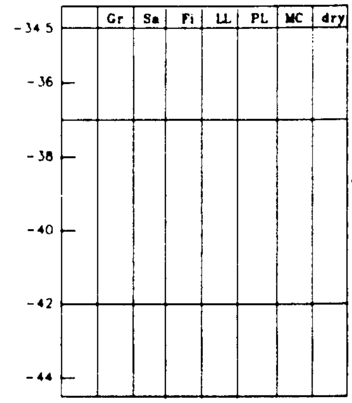
BOTTOM OF BORING -37.5 FEET MLLW

ELEV. MUDLINE -32.5 FEET MLLW
CLAY DARK GRAY, SILTY, VERY SOFT, WET, HIGH PLASTICITY

CLAY TAN, VERY STIFF, WET, HIGH PLASTICITY

2D-111

MAY 1974



BOTTOM OF BORING -44.5 FEET MLLW

ELEV. OF MUDLINE -34.5 FEET MLLW
CLAY VERY DARK GRAY, SILTY, VERY SOFT, WET, PROBABLY OF HIGH PLASTICITY

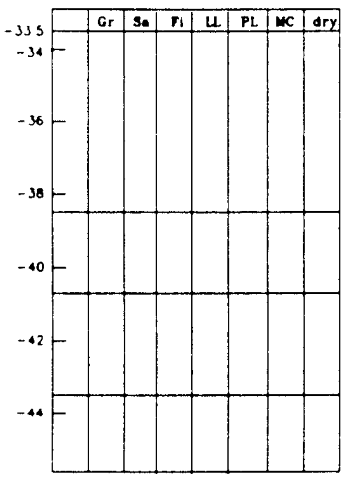
CLAY DARK GRAY, WITH SAND, VERY SOFT, WET, HIGH PLASTICITY, STRONG ORGANIC ORDOR
(ESTIMATED 25% FINE SAND)

SLIGHT ORGANIC ODOR
(ESTIMATED 15% FINE SAND AND SHELL FRAGMENTS)

CLAY DARK GRAY, SOME SAND, SOFT, WET, HIGH PLASTICITY, TRACE OF ORGANICS, SLIGHT ODOR
(ESTIMATED 10% SAND)

2D-118

MAY 1974



BOTTOM OF BORING -45.5 FEET MLLW

ELEV. MUDLINE -33.5 FEET MLLW
CLAY DARK GRAY, SILTY, VERY SOFT TO SOFT, WET, HIGH PLASTICITY

TRACE OF ORGANICS, STRONG ORGANIC ODOR

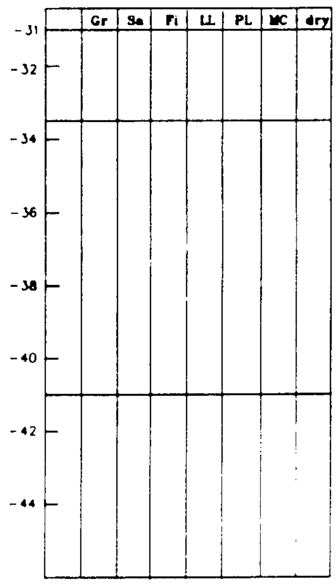
SAND DARK GRAY, CLAYEY, MEDIUM DENSE, FINE TO MEDIUM-GRAINED, SATURATED, STRONG ODOR
(ESTIMATED 45% PASSING #200 SIEVE)

CLAY YELLOWISH GRAY WITH TAN SPOTS, SOME FINE TO MEDIUM-GRAINED SAND, VERY STIFF DAMP, HIGH PLASTICITY
(ESTIMATED 10% SAND)

CLAY GRAYISH BROWN, WITH FINE-GRAINED SAND, VERY STIFF TO HARD, DAMP, HIGH PLASTICITY
(ESTIMATED 25% SAND)

2D-119

MAY 1974



BOTTOM OF BORING -46 FEET MLLW

ELEV. MUDLINE -31 FEET MLLW
CLAY VERY DARK GRAY, SILTY, VERY SOFT, WET, HIGH PLASTICITY.

CLAY BLACK-GRAY, TRACE OF SAND, VERY SOFT, WET, HIGH PLASTICITY.

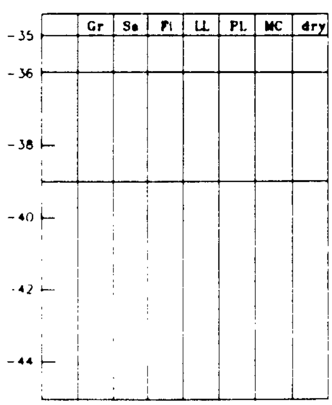
(TRACE OF SAND)
ORGANIC FIBERS AND ODOR.

(TRACE OF SAND)
ORGANIC FIBERS AND ODOR.

CLAY DARK GRAY, SILTY, SOFT WET, HIGH PLASTICITY, SLIGHT ODOR

2D-123

MAY 1974



BOTTOM OF BORING -45 FEET MLLW

ELEV. MUDLINE -35 FEET MLLW
CLAY GRAY-TAN, SILTY, VERY SOFT, WET, HIGH PLASTICITY

CLAY VERY DARK GRAY, SILTY, SOFT WET, HIGH PLASTICITY

(ESTIMATED 25% FINE SAND)

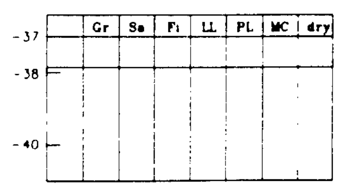
CLAY MEDIUM GRAY, WITH SAND TO SANDY, VERY STIFF, DAMP, HIGH PLASTICITY

(ESTIMATED 25% FINE SAND)

(ESTIMATED 35% FINE SAND)

2D-124

MAY 1974



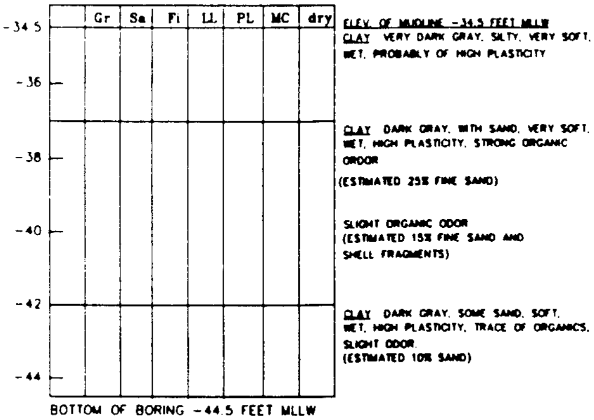
BOTTOM OF BORING -41 FEET MLLW

ELEV. MUDLINE -37 FEET MLLW
CLAY TAN TO DARK GRAY, SILTY, VERY SOFT, WET, HIGH PLASTICITY.

CLAY GREENISH GRAY, SILTY, VERY STIFF, DAMP, HIGH PLASTICITY

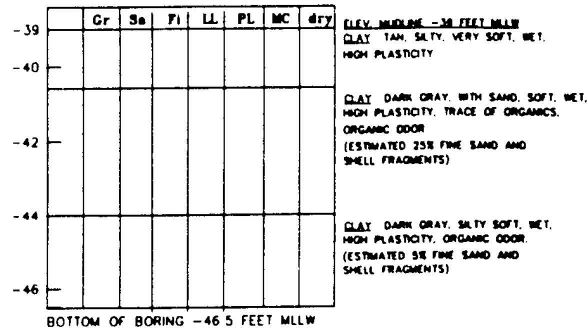
2D-111

MAY 1974



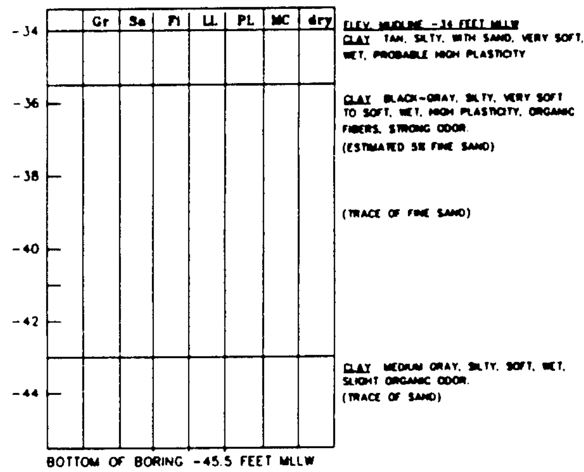
2D-112

MAY 1974



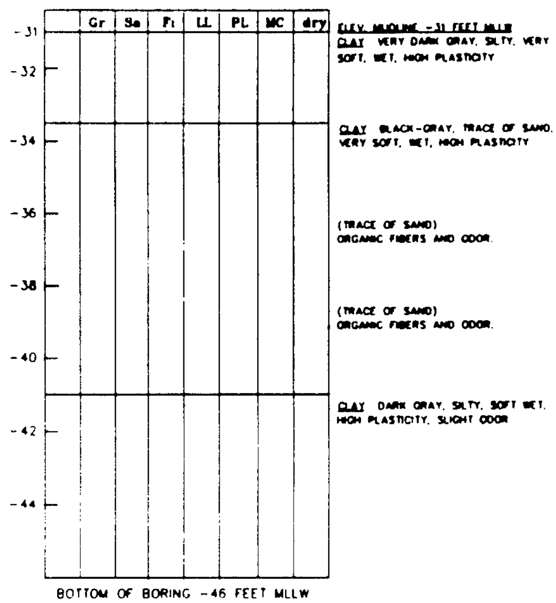
2D-121

MAY 1974



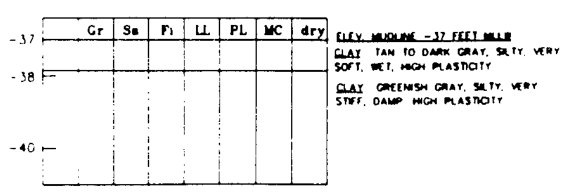
2D-119

MAY 1974



2D-124

MAY 1974



SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DESIGNED BY: PH

TRACED BY:

CHECKED BY:

SUBMITTED:

CONTRA COSTA COUNTY — CALIFORNIA

RICHMOND INNER HARBOR
LOGS OF EXPLORATION BORINGS

APPROVAL RECOMMENDED:

APPROVED:

DATE:

PREPARED UNDER THE DIRECTION OF
[illegible]
COLONEL, C.E., DISTRICT ENGINEER

SCALE | FILE No.

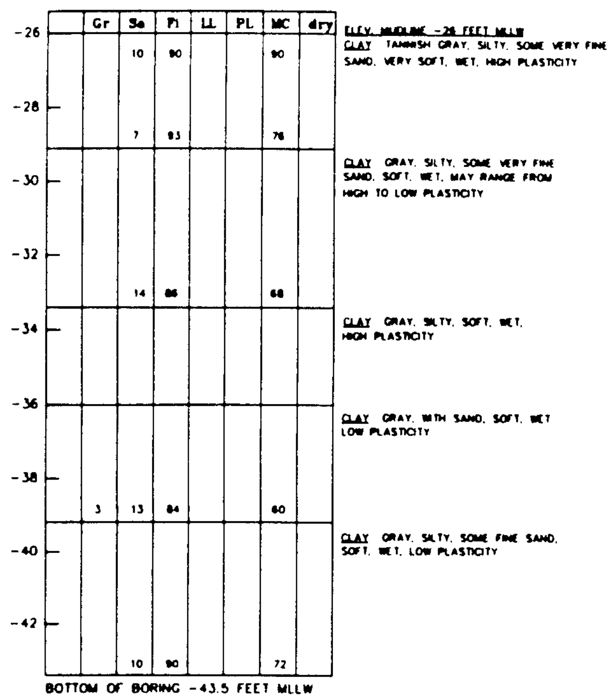
DRAWING NUMBER

SHEET 4 | 9 | 5 | 7

APP. B PLATE 8

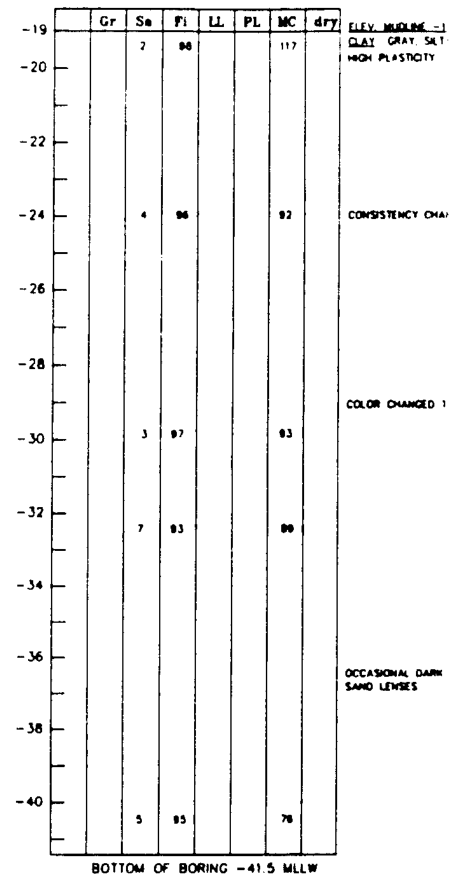
2D-140

OCTOBER 1973



2D-141

OCTOBER 1973



UDLINE -26 FEET MLLW
TANNISH GRAY, SILTY, SOME VERY FINE
VERY SOFT, WET, HIGH PLASTICITY

GRAY, SILTY, SOME VERY FINE
SOFT, WET, MAY RANGE FROM
LOW PLASTICITY

GRAY, SILTY, SOFT, WET,
ASTICITY

GRAY, WITH SAND, SOFT, WET
ASTICITY

GRAY, SILTY, SOME FINE SAND,
ET, LOW PLASTICITY

2D-141

OCTOBER 1973

Elev.	Gr	Sa	Fi	LL	PL	MC	dry	
-19								ELEV. MUDLINE -19 FEET MLLW
		2	98			117		CLAY GRAY, SILTY, VERY SOFT, WET, HIGH PLASTICITY
-20								
-22								
-24		4	96			92		CONSISTENCY CHANGED TO SOFT
-26								
-28								
								COLOR CHANGED TO DARK GRAY
-30		3	97			93		
-32								
		7	93			89		
-34								
-36								
								OCCASIONAL DARK GRAY THIN, SILTY SAND LENSES
-38								
-40								
		5	95			78		

BOTTOM OF BORING -41.5 MLLW

2

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DRAWN BY: PH

TRACED BY:

CHECKED BY: [signature]

SUBMITTED:

CONTRA COSTA COUNTY — CALIFORNIA

RICHMOND INNER HARBOR
LOGS OF EXPLORATION BORINGS

APPROVAL RECOMMENDED:

APPROVED: — DATE:

PREPARED UNDER THE DIRECTION OF
GALEN YANAGIHARA
COLONEL, C.E., DISTRICT ENGINEER

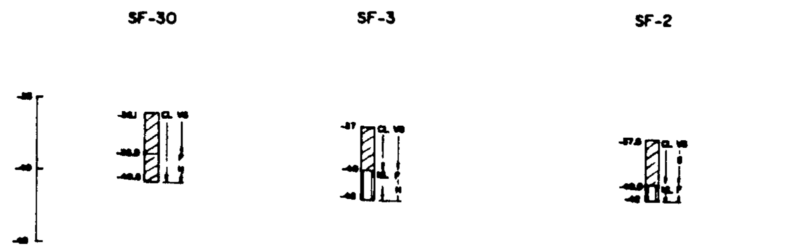
SCALE: — JOB No.:

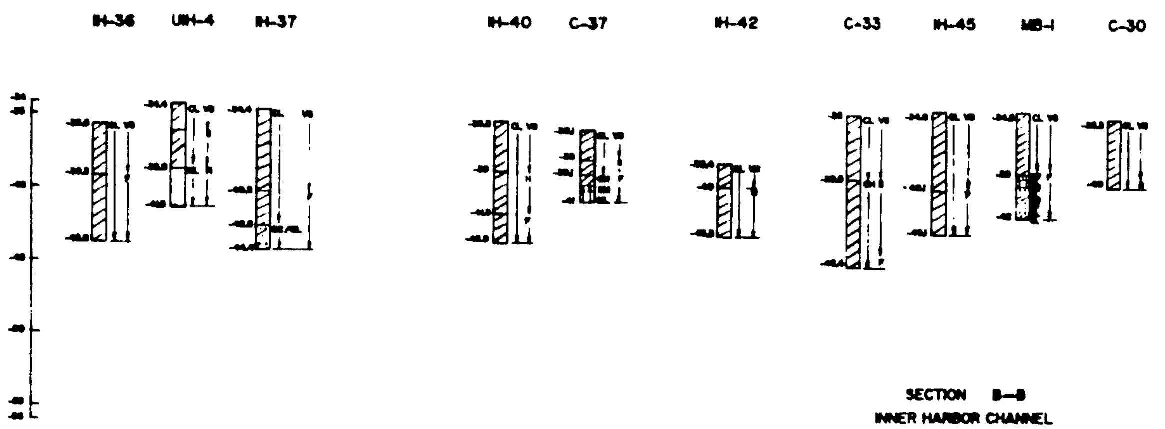
DRAWING NUMBER

SHEET 5 | 9 | 5 | 7

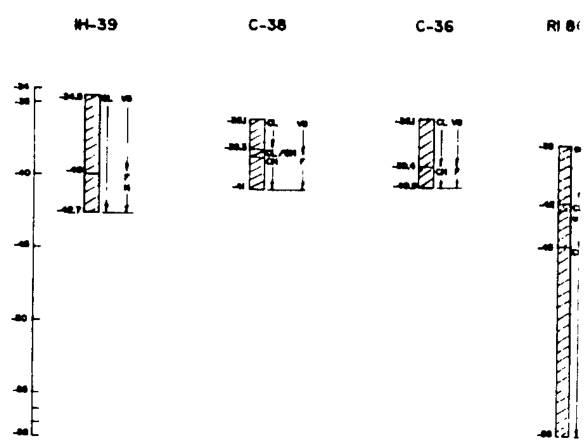
3

APP. B PLATE 9





SECTION B—B
INNER HARBOR CHANNEL



NOTES:

1. THE SYMBOLS USED GENERALLY CONFIRM TO ASTM D2488 FOR DESCRIPTION AND IDENTIFICATION OF SOILS (VISUAL MANUAL PROCEDURE).

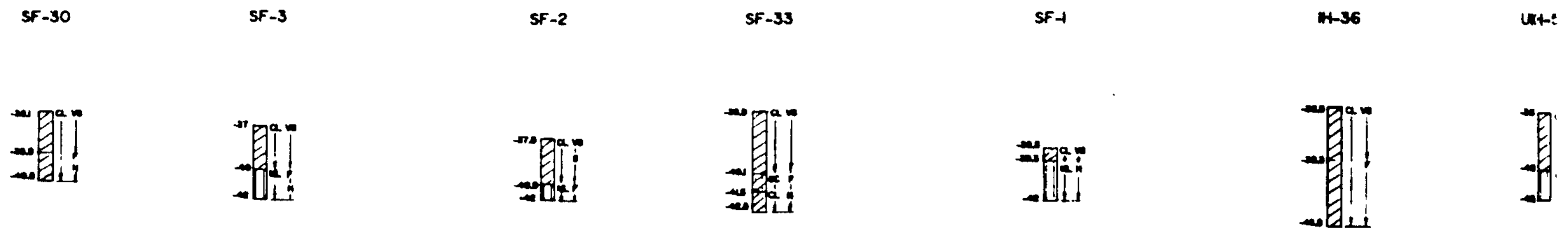
2. SOIL CLASSIFICATION:

GROUP SYMBOL	GROUP NAME	GROUP SYMBOL	GROUP NAME
GW	WELL-GRADED GRAVEL	CL	LEAN CLAY
GP	POORLY GRADED GRAVEL	ML	SILT
GM	SILTY GRAVEL	OL	ORGANIC SOIL WITH LOW PLASTICITY
GC	CLAYED GRAVEL		
SW	WELL-GRADED SAND	CH	FAT CLAY
SP	POORLY GRAVEL SAND	MH	ELASTIC SILT
SM	SILTY SAND	OH	ORGANIC SOIL WITH HIGH PLASTICITY
SC	CLAYED SAND		
PT	PEAT	SS	SANDSTONE
		SHL	SHALE

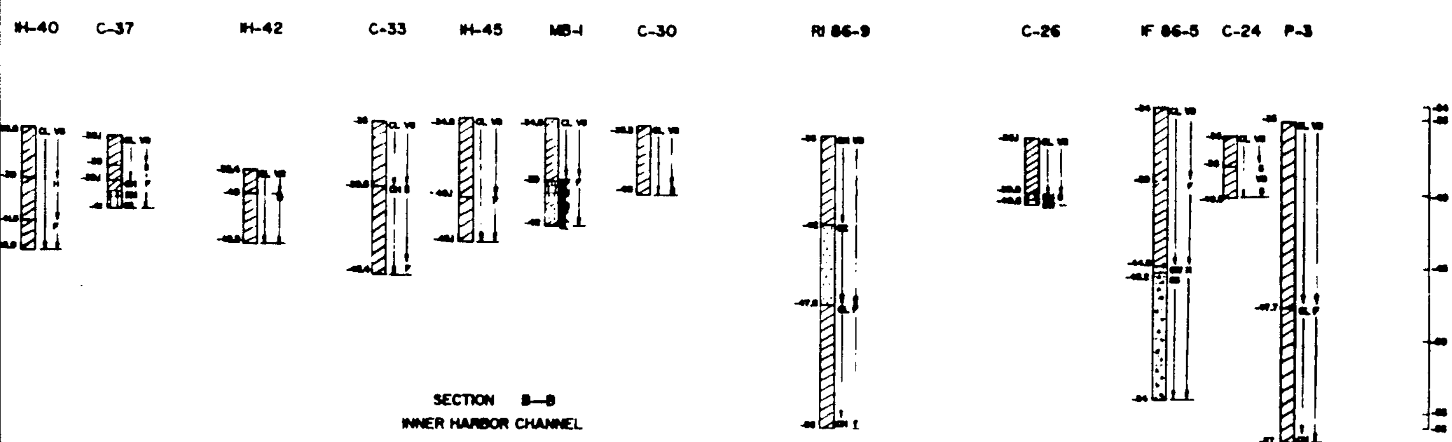
3. WHEN THE VISUAL MANUAL INSPECTION INDICATES THAT THE SOIL IS CLOSE TO ANOTHER SOIL CLASSIFICATION GROUP, THE BORDERLINE CONDITION IS INDICATED WITH TWO SYMBOLS SEPARATED BY A SLASH, FOR EXAMPLE: CL/CH, GM/SM, SC/CL.

4. CL w/SP INDICATES LEAN CLAY WITH THIN LAYERS OF POORLY GRADED SAND. SW w/CL INDICATES WELL-GRADED SAND WITH THIN LAYERS OF LEAN CLAY.

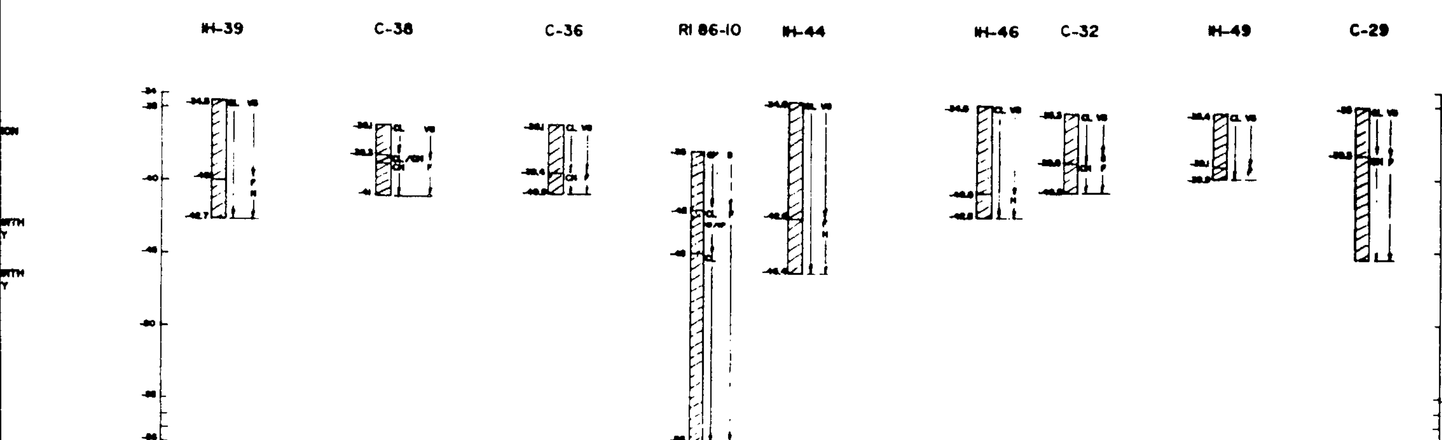
5. ALL ELEVATION ARE REFERENCED TO MEAN LOWER LOW WATER DATUM.



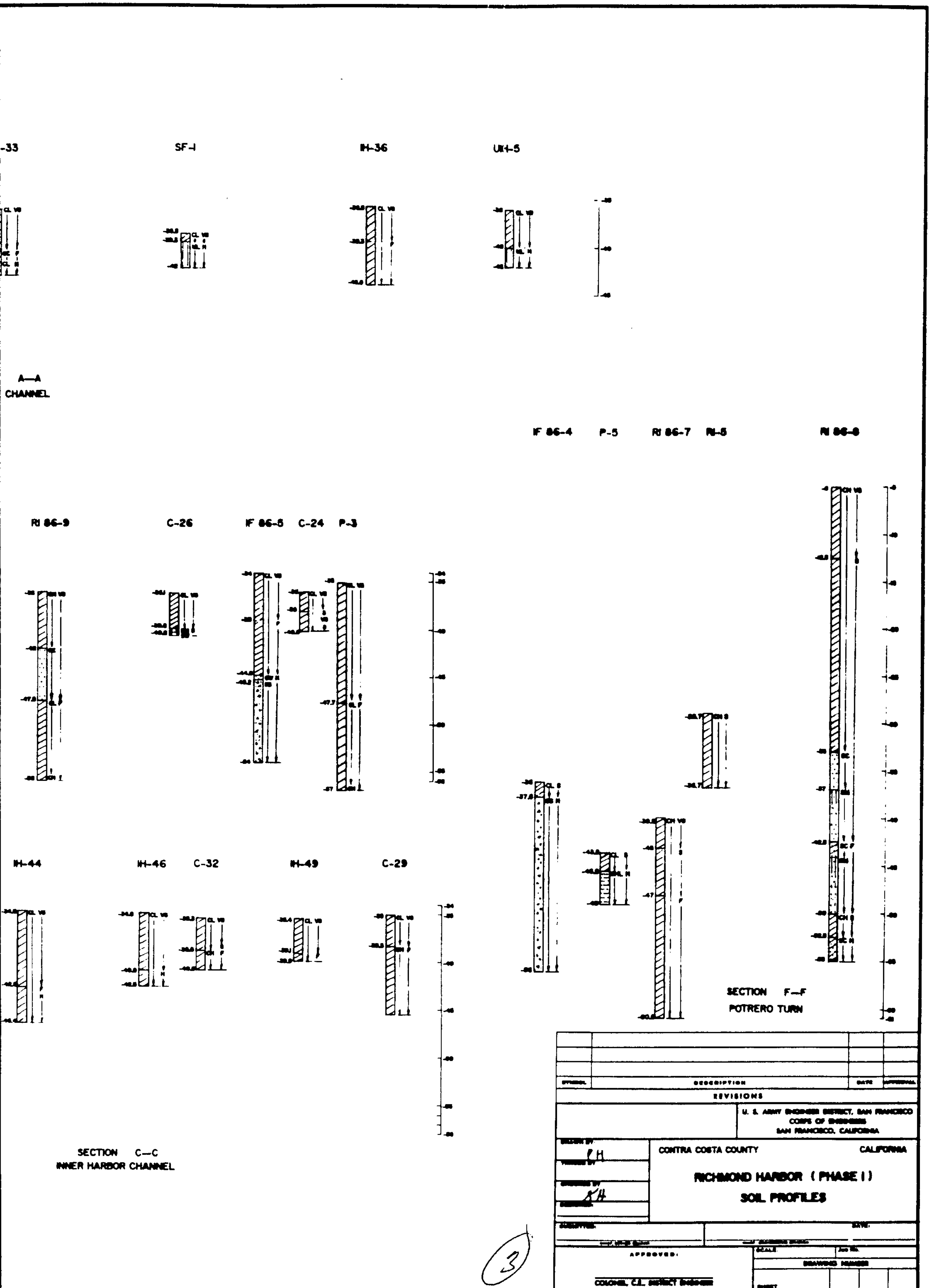
SECTION A—A
SANTA FE CHANNEL

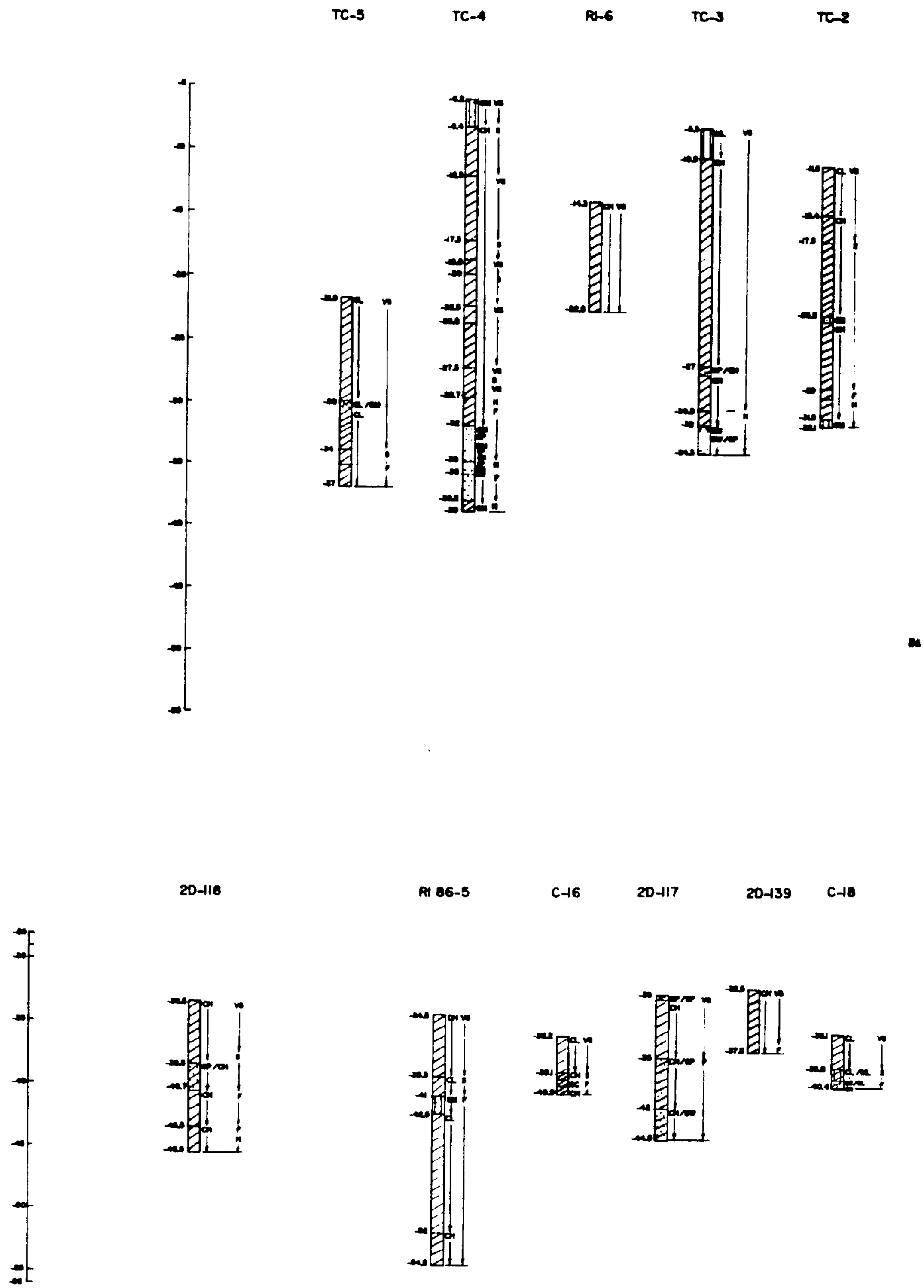


SECTION B—B
INNER HARBOR CHANNEL



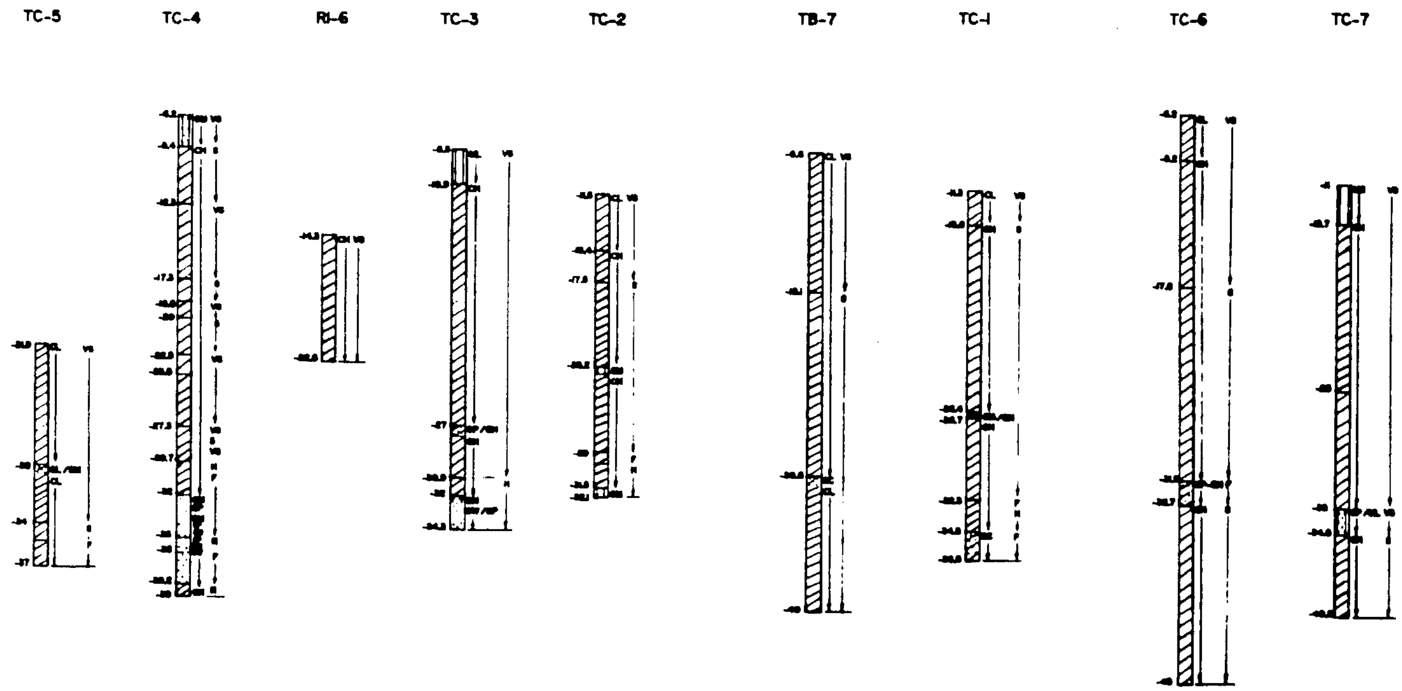
SECTION C—C
INNER HARBOR CHANNEL


-33
SF-1
IH-36
UIH-5
A—A
CHANNEL
IF 86-4
P-5
RI 86-7
RI-5
RI 86-8
RI 86-9
C-26
IF 86-5
C-24
P-3
IH-44
IH-46
C-32
IH-49
C-29
SECTION F—F
POTRERO TURN
SECTION C—C
INNER HARBOR CHANNEL
SYMBOL
DESCRIPTION
DATE
APPROVAL
REVISIONS
U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA
CONTRA COSTA COUNTY
CALIFORNIA
RICHMOND HARBOR (PHASE I)
SOIL PROFILES
APPROVED:
COLONEL, C.E., DISTRICT ENGINEER
SCALE
DRAWING NUMBER
SHEET
3

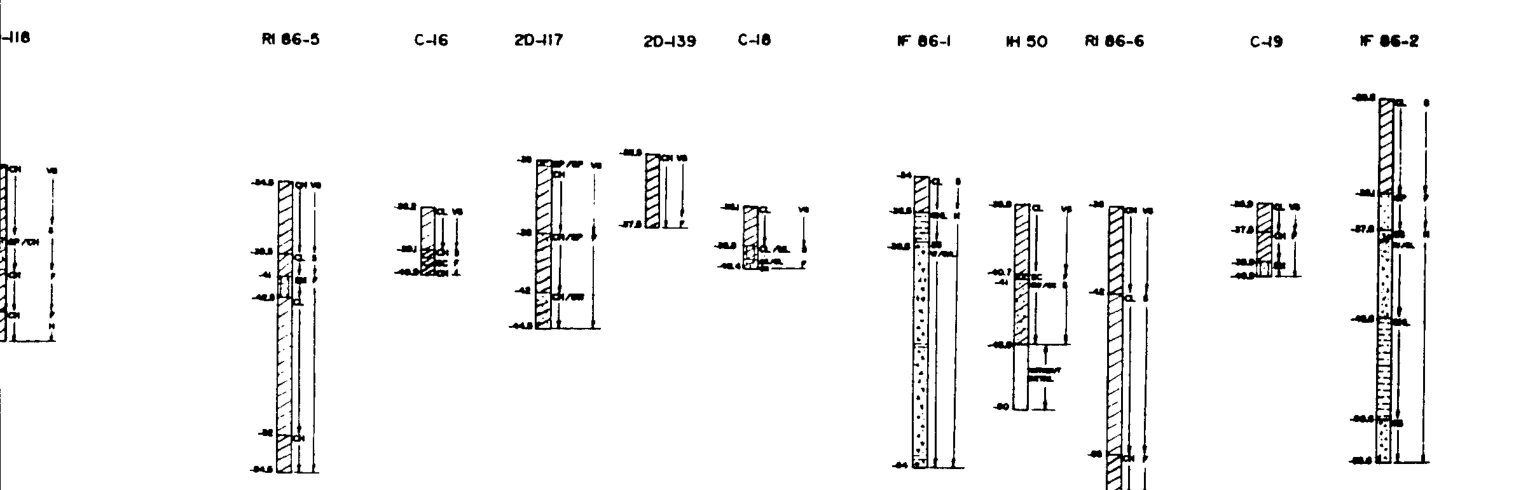


SECTION E—E
ENTRANCE CHANNEL

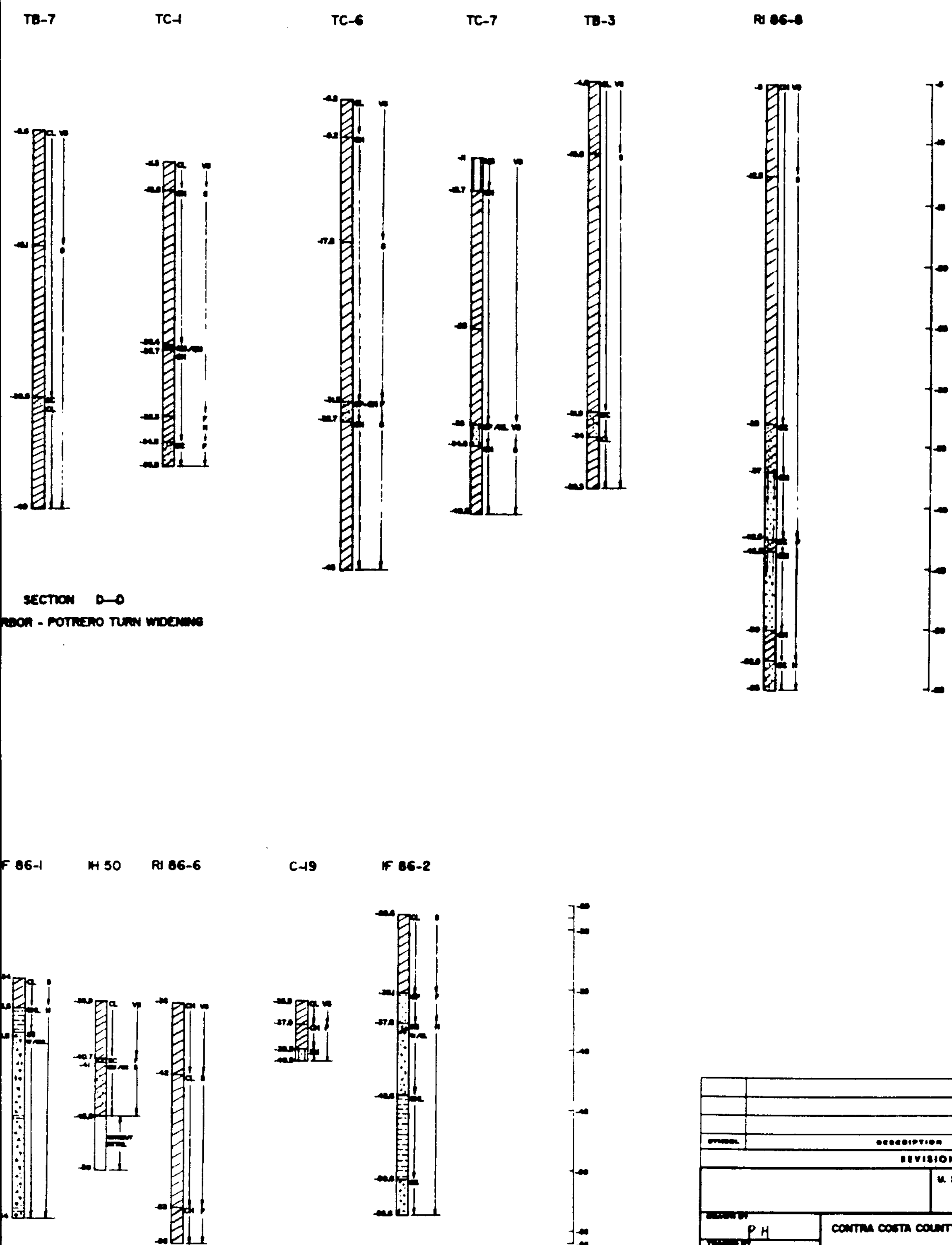
1



SECTION D—D
INNER HARBOR - POTRERO TURN WIDENING



SECTION E—E
ENTRANCE CHANNEL



REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

PH

KH

CONTRA COSTA COUNTY CALIFORNIA

RICHMOND HARBOR (PHASE I)

SOIL PROFILES

APPROVED:

DRAWING NUMBER

Appendix B

WES Navigation Simulation

RICHMOND HARBOR TURNING BASIN SHIP SIMULATION STUDY

INTRODUCTION

1. Background. The Richmond Harbor deepening project calls for increasing channel depths from the present 35 ft to the proposed design depth of 38 ft. Figure 1 presents the configuration of the ship channels in Richmond Harbor. A recent navigation chart of the study area is presented as Figure 2. Ship simulations were conducted to address the overall channel design issues and these earlier test results were furnished your office in 1987 for use in design. The resulting turning basin design was located somewhat north of Potrero Point as shown on Figure 3. As a result of subsequent investigation, potentially hazardous material was found in the original turning basin as developed from the previous simulation test results. Additional economic analysis resulted in the turning basin being relocated and redesigned to reduce the amount of dredging. The resulting two turning basins are shown on Figure 3 as Alternatives No. 1 and No. 2.

2. Purpose and Scope. The primary concern of the present study was to verify the feasibility of relocating the turning basin and to optimize its size. The previous simulation databases were reconstituted, updated, and revalidated. New databases were developed for the existing and two proposed turning basins and installed on the simulator. The primary purpose of the study was to ensure minimum turning basin dimensions consistent with safety. The San Francisco Bay mathematical model was used to develop tidal current patterns in the three test turning basins located near Potrero Sharp Turn. Two professional pilots from the San Francisco Bar Pilots assisted in the tests by piloting the simulated ship in the study area. The tests were conducted with the previously used 855-ft long, 106-ft beam bulk carrier loaded to drafts of 33 and 36 ft in the existing and two proposed turning basins, respectively. The detailed configuration of the three turning basins are depicted on Figure 4.

3. Test Procedure. The San Francisco Bay mathematical model as presently implemented in the Estuaries Division, Hydraulics Laboratory, was used to develop tidal currents for use in the simulation tests. Details of the model results from these computations are presented as Appendix A to this report. Figure 5 gives the tidal elevation in Richmond Harbor when the maximum easterly and westerly tidal currents occured. The tidal currents were developed in the vicinity of Potrero Point and installed for the existing and the two alternative turning basin plans. Maximum tidal currents were used in the simulations and were about 0.25 fps (.15 knots) in the easterly direction and 0.50 (.3 knots) fps in the westerly direction, as depicted on Figures 6 and 7. The tidal current patterns used in each ship simulation

scenario is shown on Figures 8-13.

4. Simulation testing concentrated on the turning basin design itself rather than the harbor channels which had been presviously simulated. Test conditions included the three turning basin designs, the two current directions, two professional pilots, and three types of tests. Those were (a) inbound ship with turning about in the turning basin and proceeding stern-first under tug assist into the upper harbor, (b) inbound ship proceeding bow first around Potrero Point into the upper harbor, and (c), outbound ship proceeding around Potrero Point. Table presents a summary of test conditions used in the simulations. The first pilot revalidated the simulation and conducted some turning basin design tests; the second pilot conducted a larger number of tests, including some limited outbound test runs.

STUDY RESULTS

5. The ship track test results of the turning basin simulations are summarized on individual plots on Figures 14-28; similar plots are presented for the inbound ship transits on Figures 29-42. Outbound test runs are presented on Figures 43-47. The following paragraphs discuss these test results.

6. Turning Basin Tests. The test results show that the existing turning basin operational strategy is to bring the ship bow into the notched turning basin and, while holding the ship bow in position with one tug, turn the ship stern clockwise until the ship lines up with the Harbor Channel. The ship can then be maneuvered stern-first using astern power and controlling the ship using the two tugs to maintain mid-channel position. The test results on Figures 14, 15, 20, and 21 show the results of these tests. Turning the ships in the existing turning basin is very slow and requires careful monitoring of ship position. By contrast, test results in either alternative plans as shown on Figures 16-19 and 22-26 allows both ship bow and stern to be rotated using the two tugs at the ship stern and bow. This allows a much more rapid maneuver and the larger turning area increases the safety of the operation. There does not appear to be any difference in maneuvering ability between the two alternatives, or tidal current direction.

7. Inbound Tests. The turning maneuver around Potrero Point as shown on Figures 29-42 is a rather straight-forward operation and does not appear to be a function of turning basin design or current direction. The strategy is to reduce ship speed and position the ship close to outside of the turn; then, using ship rudder and tugs initiate the turn near abeam of beacon No. "12". The ship can then be controlled with the ship rudder and tugs as required toward a berth in the Richmond Harbor Channel.

8. Outbound Tests. A limited number of outbound tests were conducted with the ship maneuvering around Potrero Point and the results are shown on Figures 43-47. Neither the turning basin design or the current direction seems to have any particular effect on the ability to steer the ship safely for outbound runs.

PILOT COMMENTS

9. Pilot No. 1

"This test run was---Alternate #1 which is a great improvement over the present [existing] turning basin. It allows the turn to be made more centered in the channel and provides better clearances from [the] edge of the channel. Also, natural physical features (i.e., dock face) provides for better natural ranges to monitor turn position.

"[The navigation] aids provided at the corners of the turning basin are sufficient. If the forward range on Potrero Reach was at the edge of the dredged channel it would help mark the channel [turning basin] boundary as well.

"This test run was---Alternate #2 which is an improvement over the present turning basin, but not as good---as Alternate #1. It provides better clearances than the present turning basin, but due to the configuration of the corner of the pier on the opposite side, the turn is still made higher in the basin than [at] present (same as Alternate #!). Also, this alternate provides reduced clearance for inbound vessels in the vicinity of buoy #16.

"In Alternate #1, buoys at eh corners of the turn would be sufficient. However, in Alternate #2, a small buoy could be placed in a position similar to the north corner buoy in Alternate #1 instead of at the corner to aid in the turn. This would be in addition to present buoy #16 and moving the forward range to the edge of the channel [turning basin].

"Clearly, from a navigation point of view, Alternate #1 is better. However, if dredging costs, etc., do not justify Alternate #1, perhaps a modification between #1 and #2 could be developed."

10. Pilot No. 2

"I ran multiple simulation tests to evaluate Richmond Harbor turning basin (Potrero Point, CA) improvements. These tests consisted of simulated harbor transits inbound without a turn around (straight in) and transits with a tug assisted turn around at Potrero Point with a backing into Richmond Harbor channel. I [ran] tests of the existing conditions, proposed alternative 1 and proposed alternative 2, both with easterly and westerly setting [tidal] currents.

"First, as a pilot, I must say I would want the largest maneuvering area possible. After these tests I am ot the opinion that the difference between proposed alternatives 1 and 2 is not

significant as far as the turn and backing-in maneuver.

"However, in the straight in approach, the practice is to maneuver the ship as close to the south side of the channel in the vicinity of marker #12 and to begin the turn from this position. This allows the bank cushion/suction effect to assist in making the turn and helps keep the ship away from the corner at Potrero Point. There are frequently ships/barges moored at Potrero Point as a lay berth and the maneuvering room is reduced by as much as 150 ft! Also, there is a previous history of uncharted obstructions within 200 ft of Potrero Point, so this area must be avoided.

"My recommendation is to approve alternative 2, with the following modification. Take the area not dredged from alternative 1, (area A on sketch) and dredge an **equal** area as shown (area B) from the south side of the channel near marker #12. This would greatly facilitate the unassisted entrance to the Richmond Harbor Channel and also provide an additional distance for outbound ships to make the turn into the Potrero Reach. This dredging on the south side would also be compensated for by not having to dredge the north side as per the alternative 1 proposal.

"Should this south side dredging (compensated for by other areas not required to be dredged) not be approved, I must recommend alternative 1 as the one which provides the largest, safest, and most efficient maneuvering area of the two proposals."

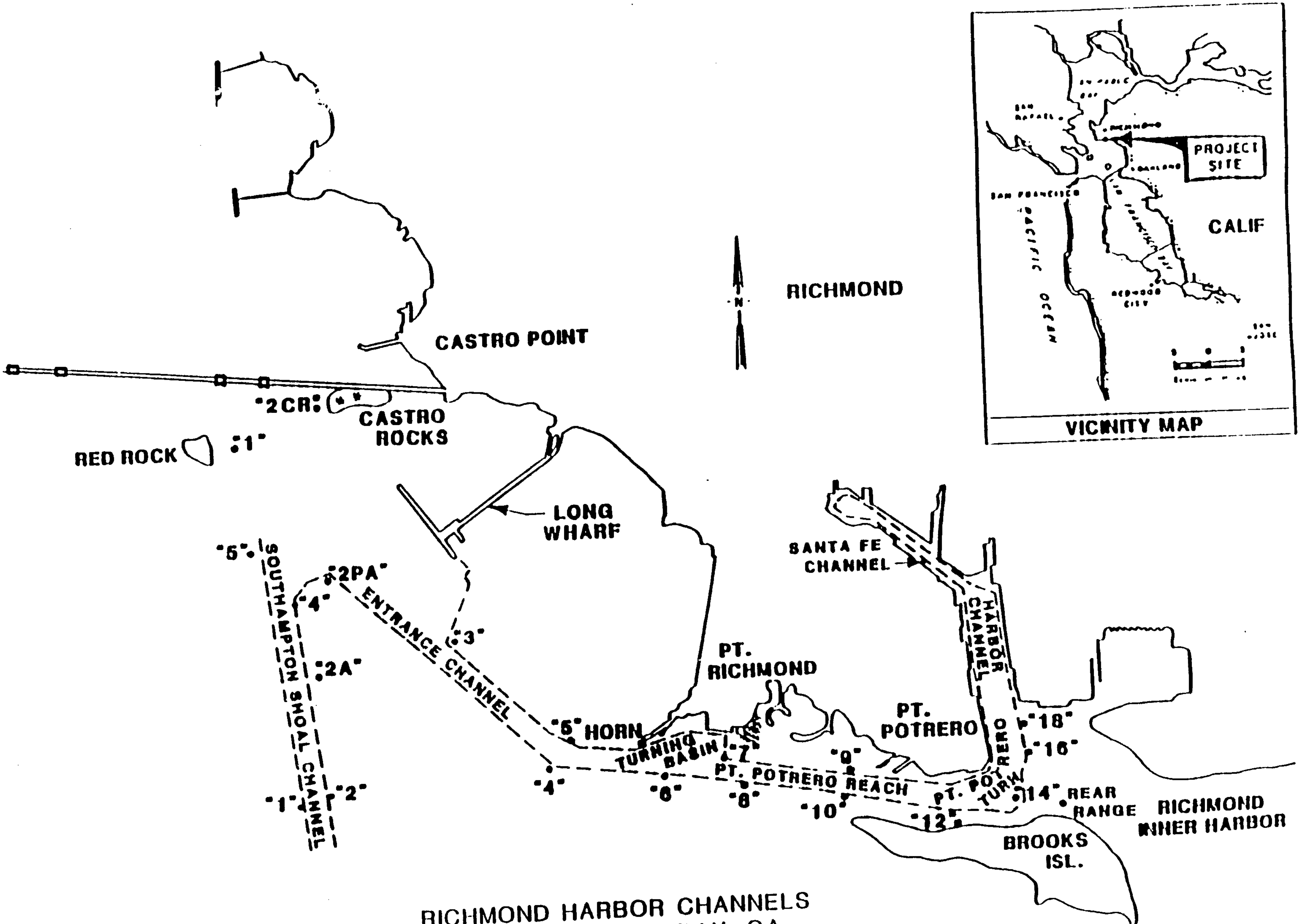
SUMMARY AND RECOMMENDATIONS

11. The study results showed that the existing Richmond Harbor turning basin was inadequate due to very slow and inefficient ship turning operations. Either of the two plans proposed by the District and tested on the simulator using local professional pilots should provide an adequate design. Both pilots preferred the largest turning basin plan, Alternate 1, because it provided the maximum clearance dimensions. The test results show that the ship tracks did not encroach into the triangular area shown on Figure 48. This recommended design is between Alternates 1 and 2 and includes modifications to the present navigation aids as suggested by the pilots.

TABLE 1: TEST CONDITIONS
Simulations Conducted

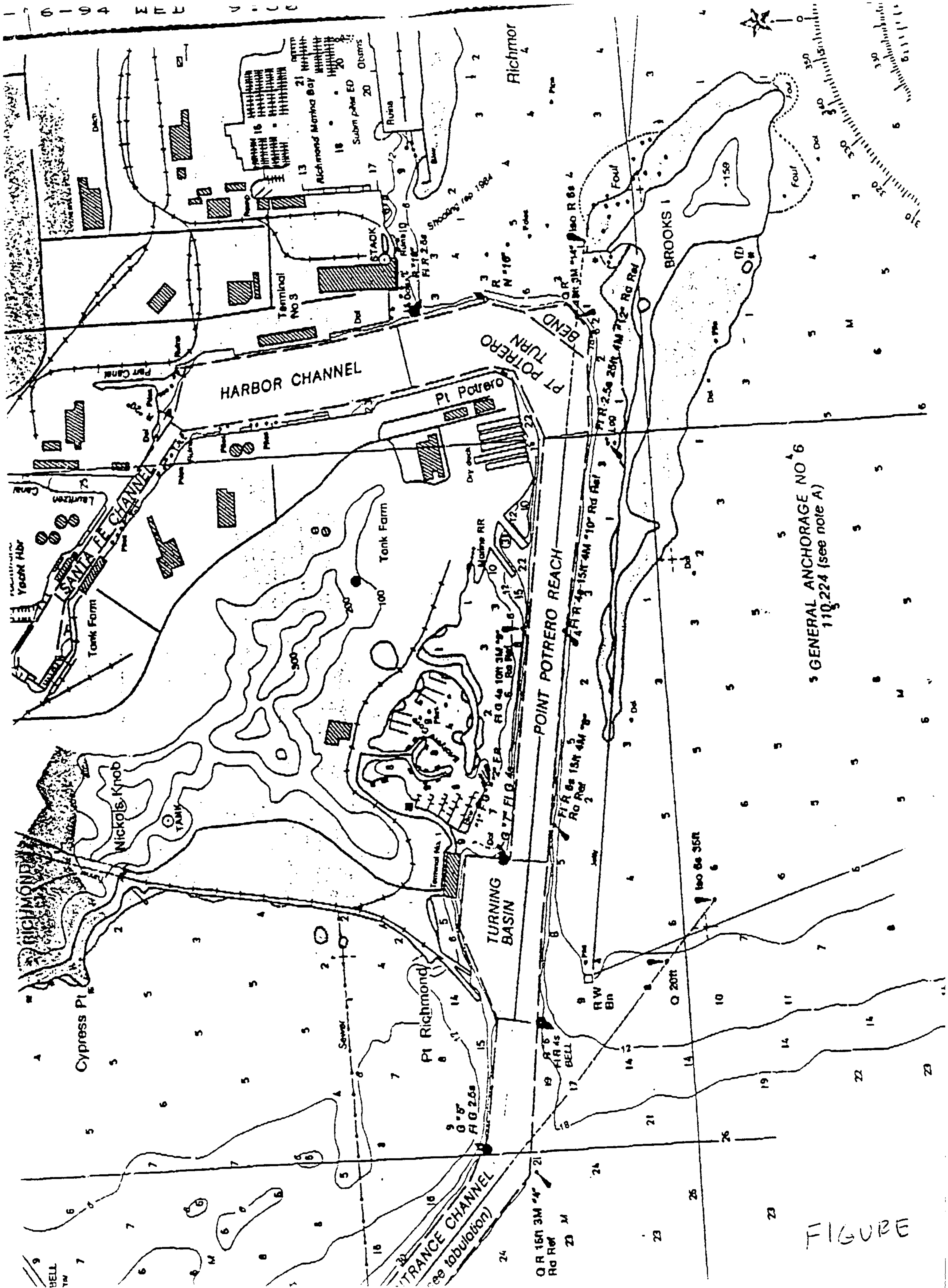
Test No.	Pilot No.	Type of Test			Turning Basin Plan			Current	
		Turn Basin	In-bound	Out-bound	Exis-ting	Alt #1	Alt #2	E	W
1	1	X			X			X	
2	1	X			X				X
3	1	X				X		X	
4	1	X				X			X
5	1	X					X	X	
6	1	X					X		X
7	2	X			X			X	
8	2	X			X			X	
9	2	X				X		X	
10	2	X				X		X	
11	2	X				X			X
12	2	X				X			X
13	2	X					X	X	
14	2	X					X		X
15	2	X					X		X
16	1		X		X			X	
17	1		X		X				X
18	1		X			X		X	
19	1		X			X			X
20	1		X				X	X	
21	1		X				X		X
22	2		X		X			X	
23	2		X		X				X
24	2		X			X		X	
25	2		X			X			X

Test No.	Pilot No.	Type of Test			Turning Basin Plan			Current	
		Turn Basin	In-bound	Out-bound	Exis-ting	Alt #1	Alt #2	E	W
26	2		X			X			X
27	2		X				X	X	
28	2		X				X	X	
29	2		X				X		X
30	2			X	X				
31	2			X		X			
32	2			X		X			
33	2			X			X		
34	2			X			X		



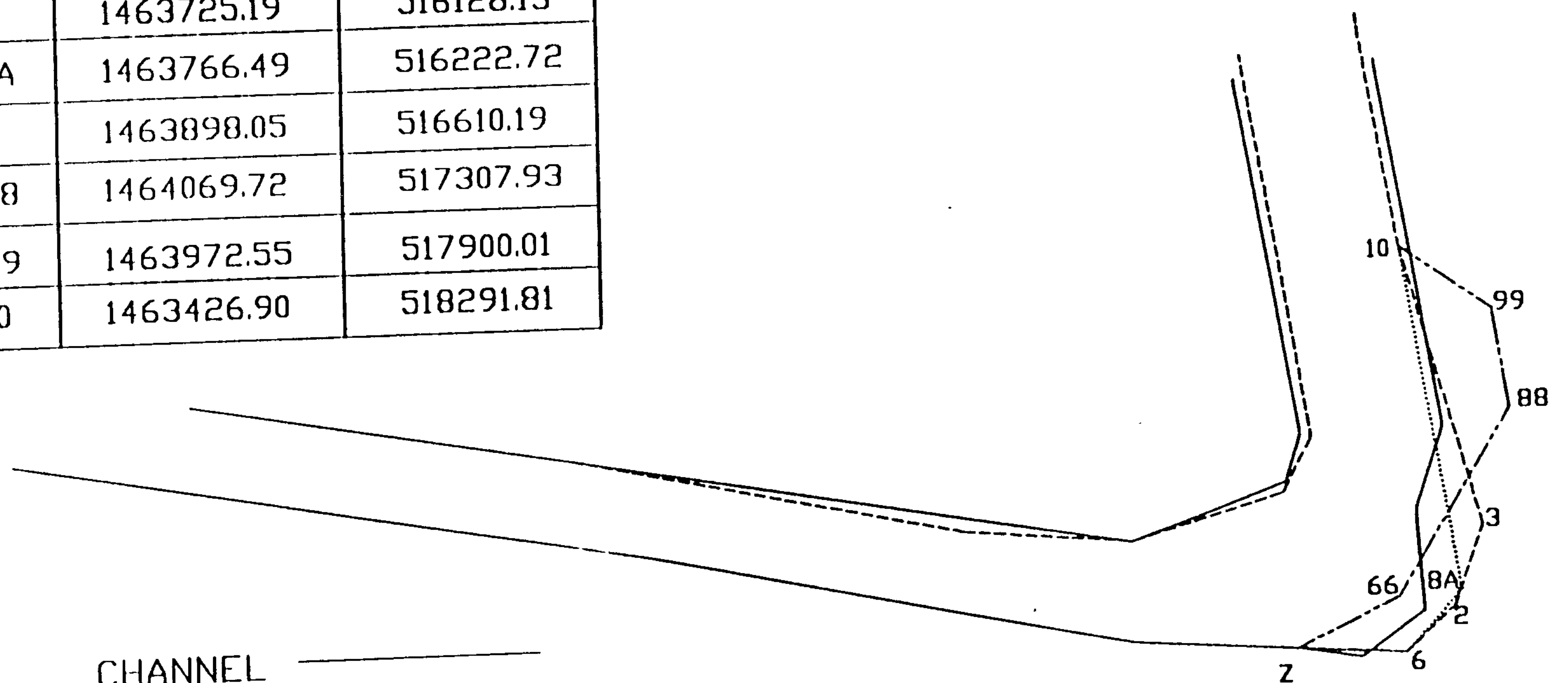
RICHMOND HARBOR CHANNELS
SAN FRANCISCO BAY, CA

FIGURE


RICHMOND
Nickols Knob
TANK
Cypress Pt
Pt Richmond
Sewer
TURNING BASIN
Terminal No. 1
POINT POTRERO REACH
ENTRANCE CHANNEL
(see tabulation)
SANTA FE CHANNEL
Yacht Hbr
Tank Farm
HARBOR CHANNEL
Pt Potrero
PT POTRERO TURN
BEND
Dry dock
Marine RR
Terminal No 3
STACK
Shoaling rep 1984
Richmond Marina Bay
Richmor
Ruins
BROOKS I
Foul
GENERAL ANCHORAGE NO 6
110.224 (see note A)
R W Bn
BELL
Q 20ft

FIGURE

<.	X	Y
Z	1462773.34	515893.70
6	1463430.14	515848.85
66	1463393.92	516190.62
2	1463725.19	516128.13
8A	1463766.49	516222.72
3	1463898.05	516610.19
88	1464069.72	517307.93
99	1463972.55	517900.01
10	1463426.90	518291.81



CHANNEL ——————

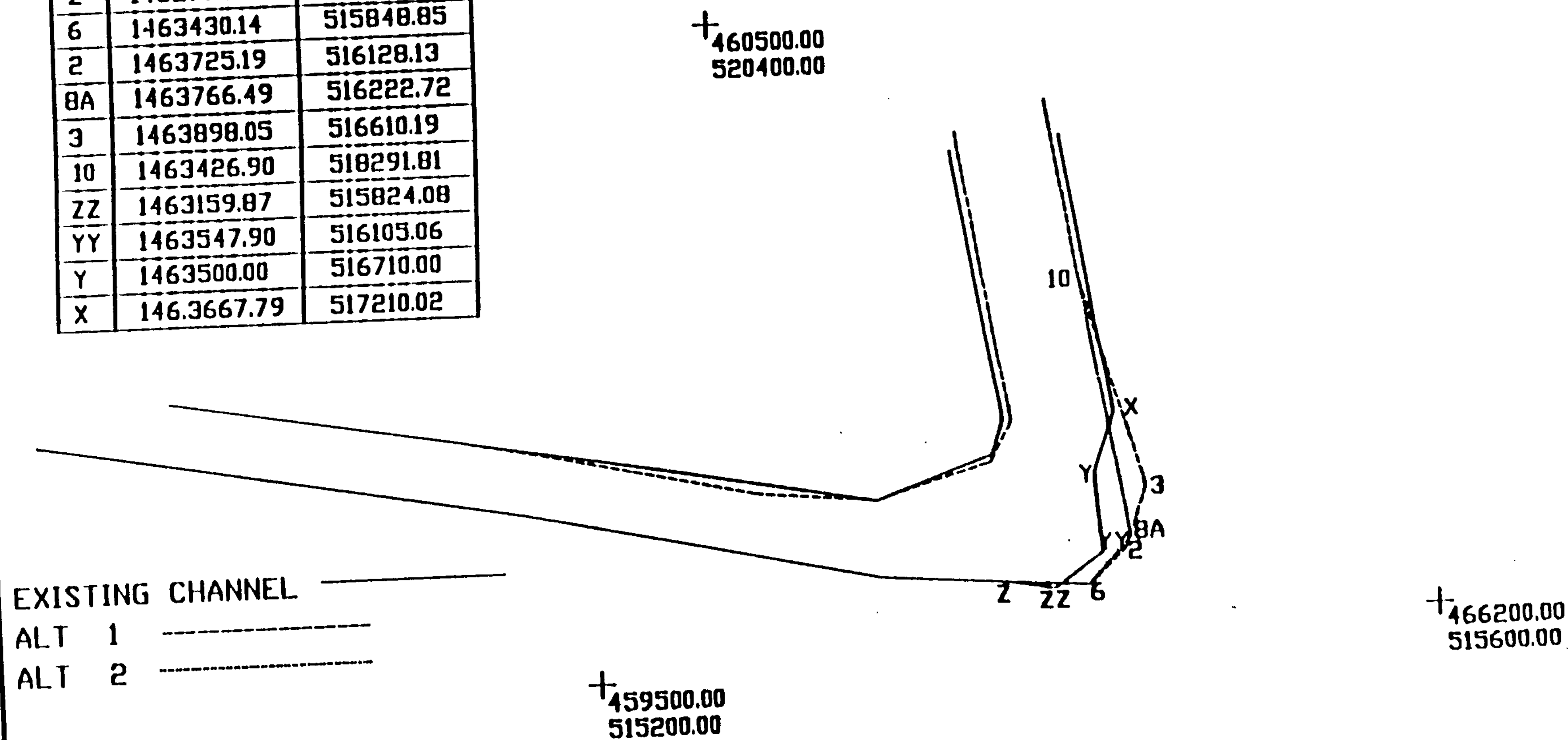
UPDATE ORIG TURNING BASIN -·-·-·-·-·-

ALT 1 ------------------

ALT 2 ....

FIGURE

∠.	X	Y
Z	1462773.34	515893.70
6	1463430.14	515848.85
2	1463725.19	516128.13
8A	1463766.49	516222.72
3	1463898.05	516610.19
10	1463426.90	518291.81
ZZ	1463159.87	515824.08
YY	1463547.90	516105.06
Y	1463500.00	516710.00
X	146.3667.79	517210.02



Channel Alignment Alternatives
Critical Channel Turn

FIGUR

Tidal Variation in Richmond Harbor

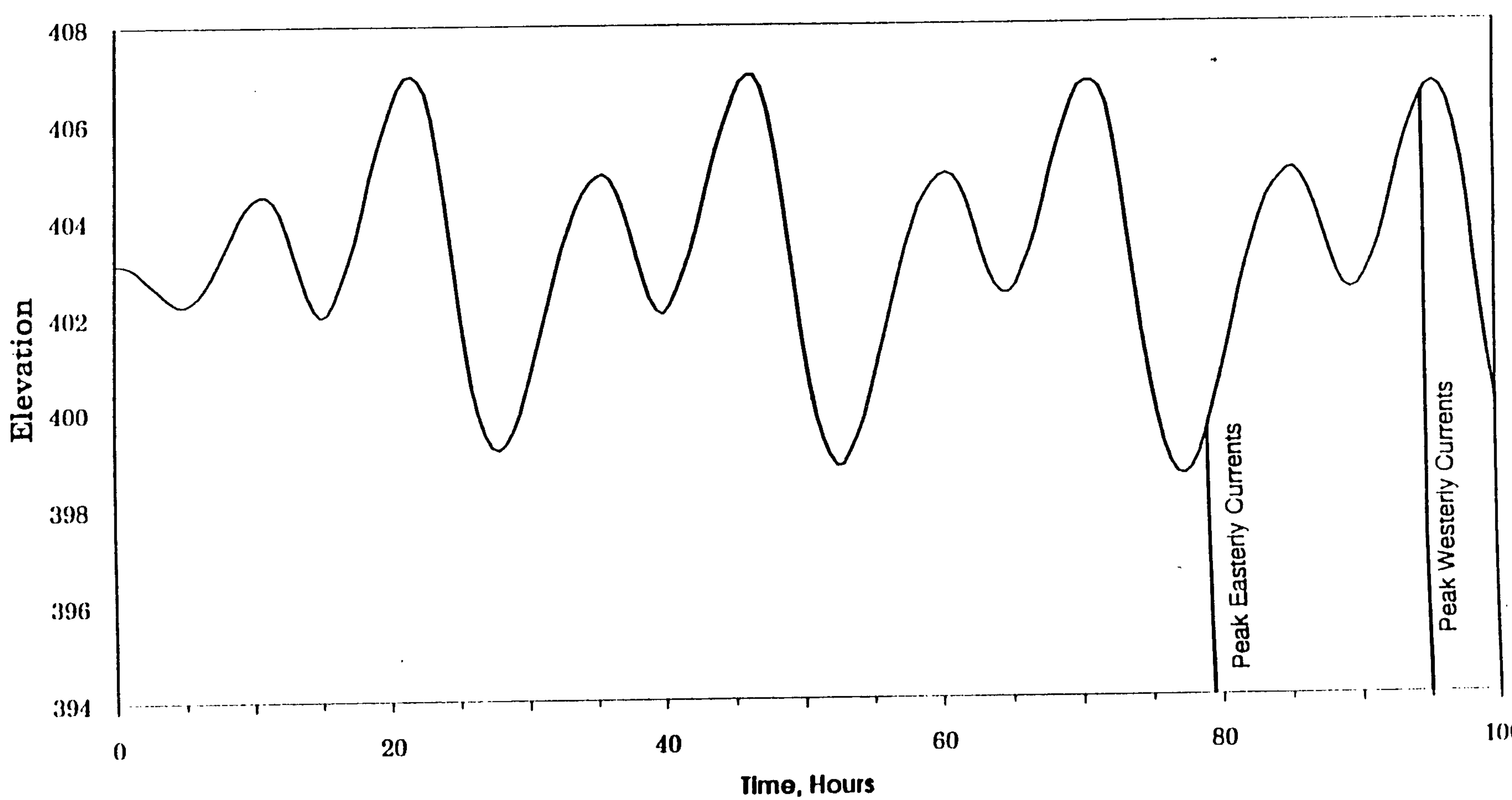
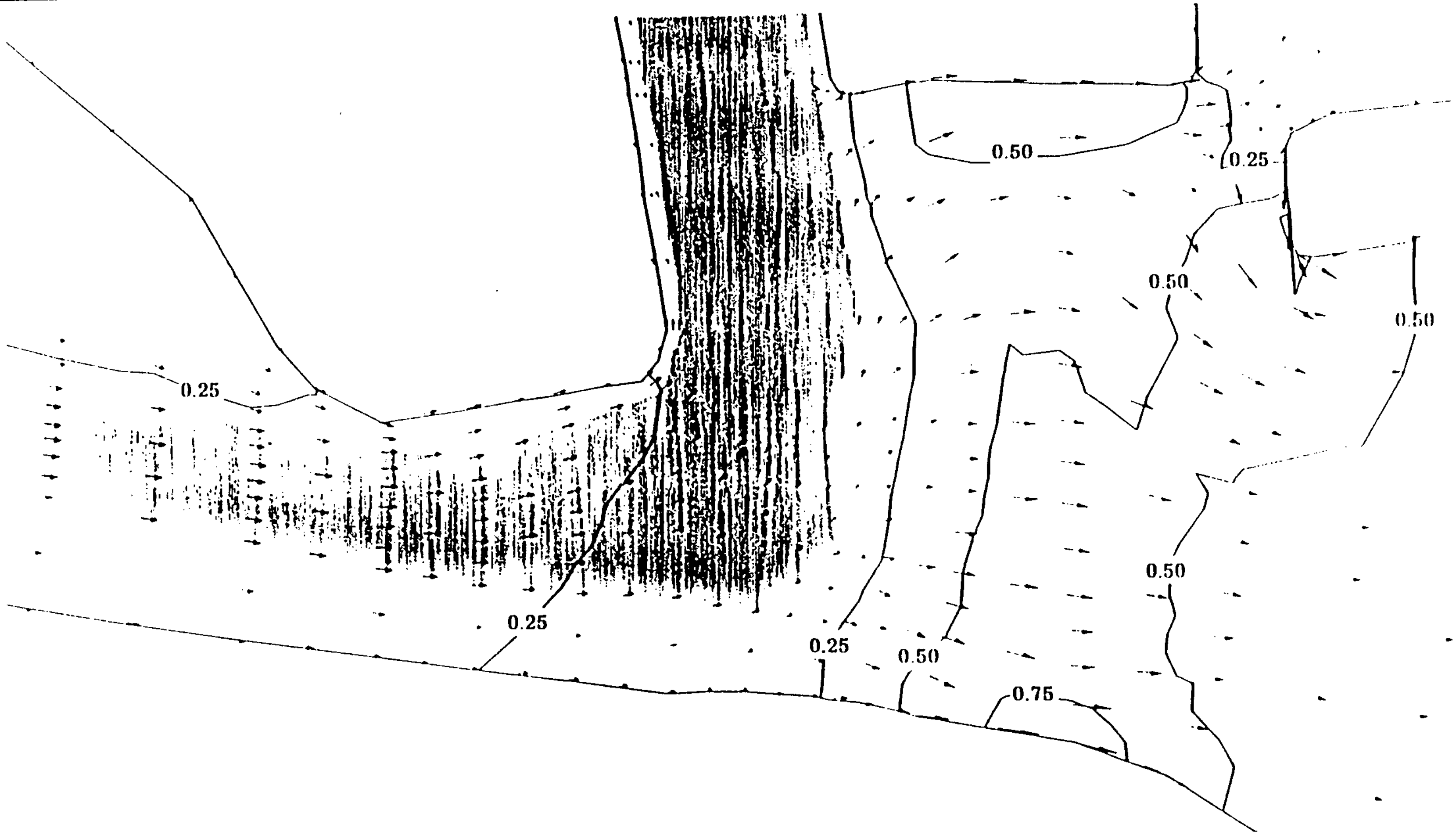
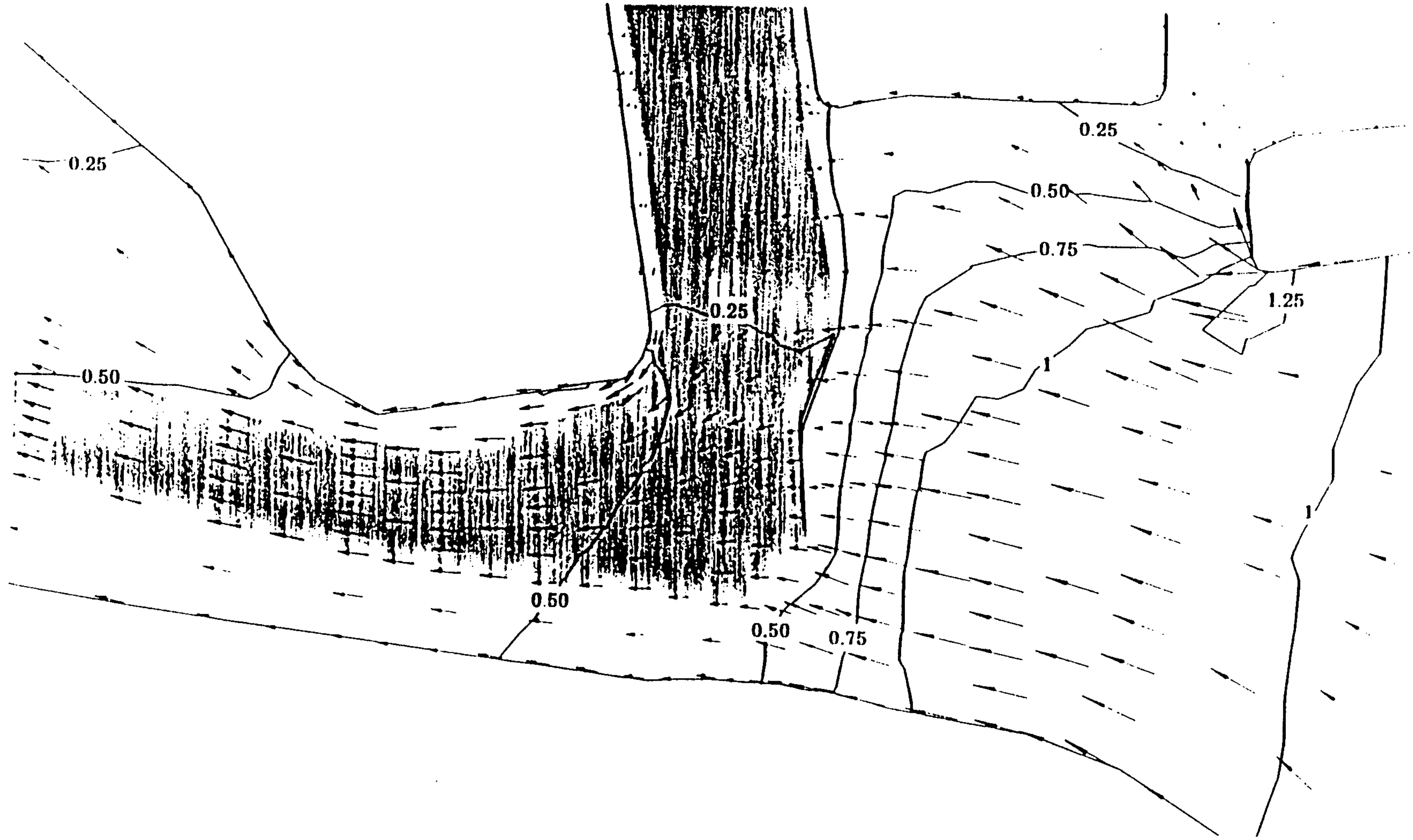


FIGURE 5



Local Circulation Patterns
Peak Easterly Currents in Richmond Harbor
Existing Channel

FIGURE

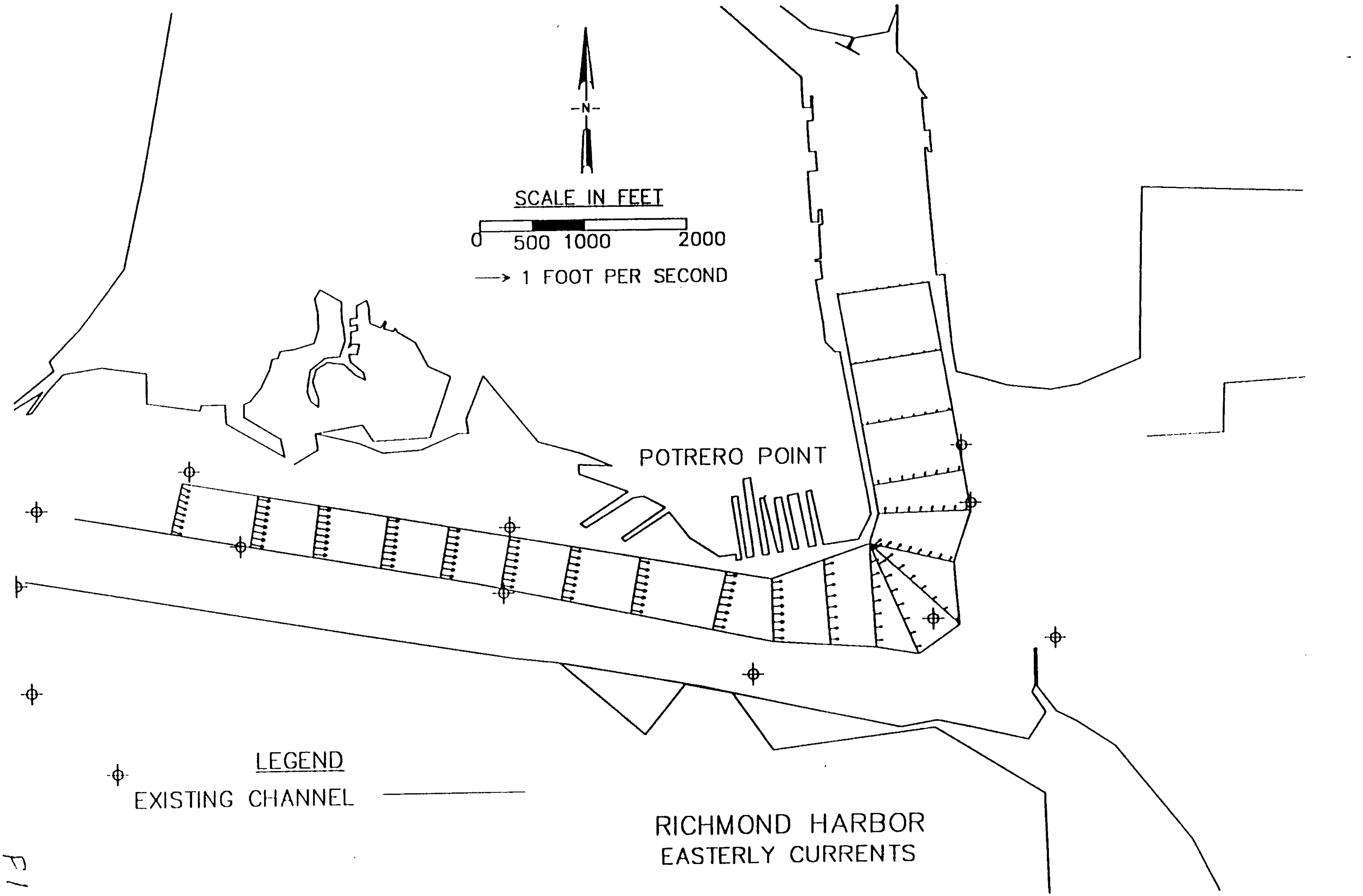


Local Circulation Patterns

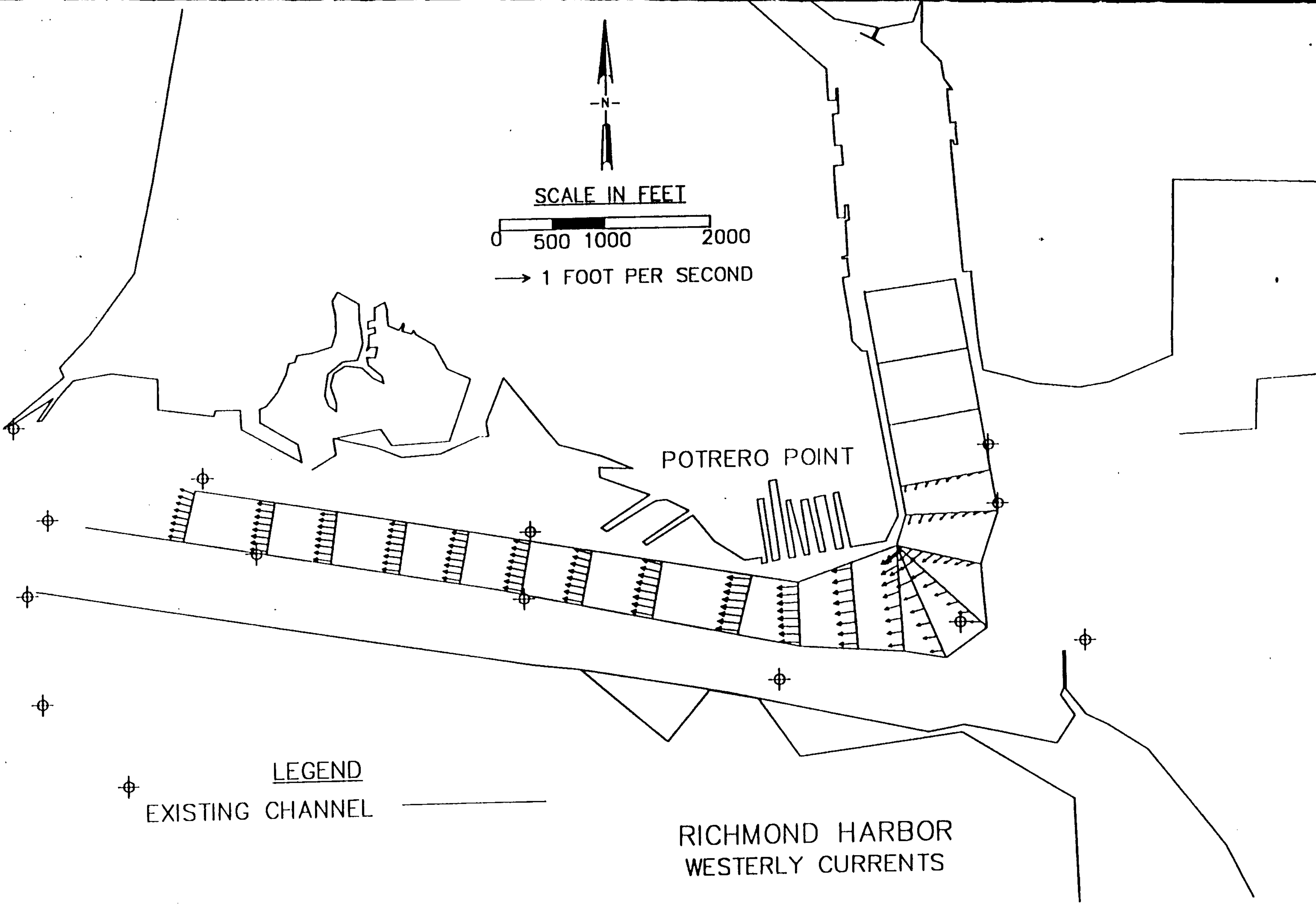
Peak Westerly Currents in Richmond Harbor

Existing Channel

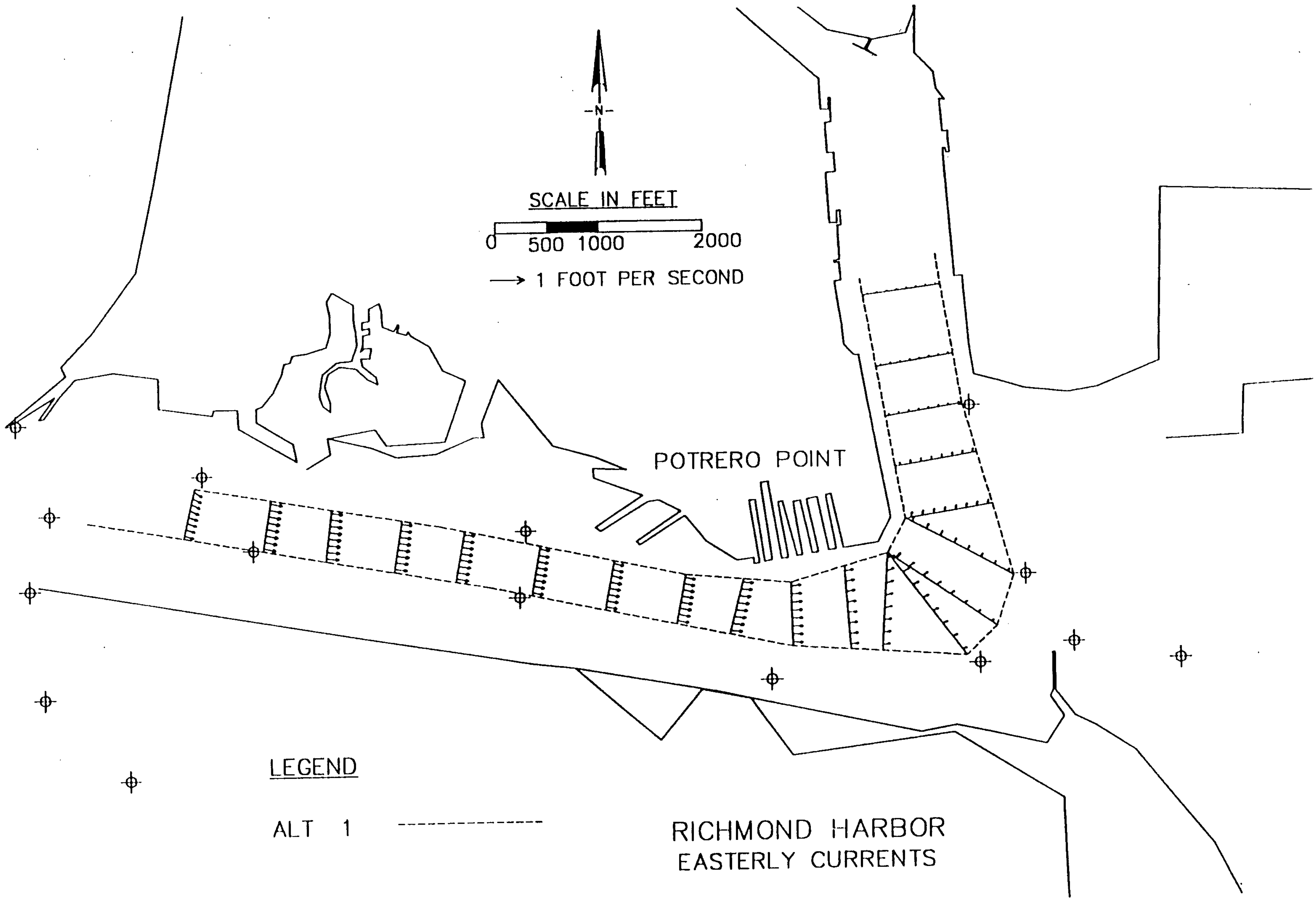
FIGURE 7


N
SCALE IN FEET
0 500 1000 2000
1 FOOT PER SECOND
POTRERO POINT
LEGEND
EXISTING CHANNEL
RICHMOND HARBOR
EASTERLY CURRENTS

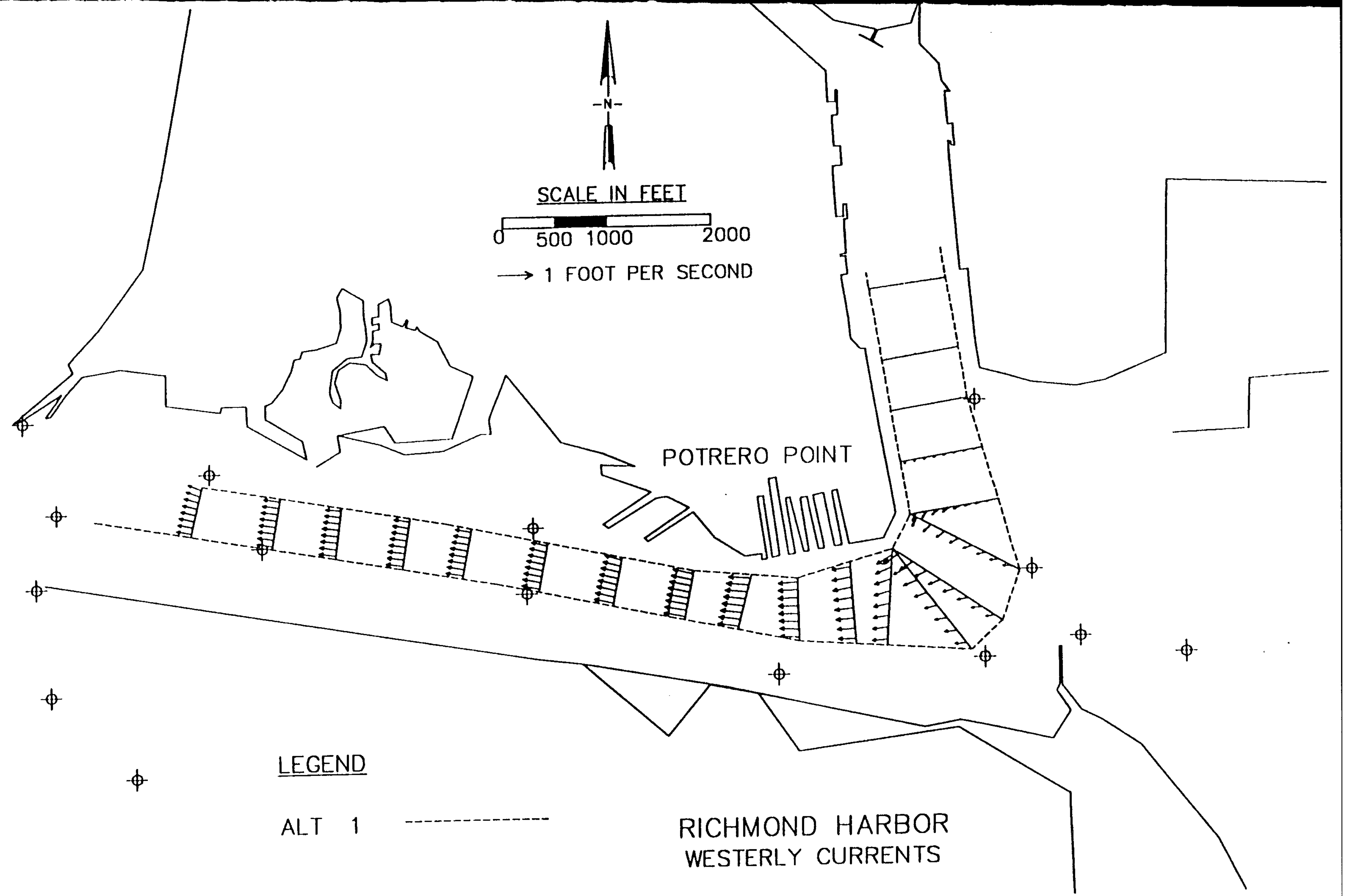
FIGURE


N
SCALE IN FEET
0 500 1000 2000
1 FOOT PER SECOND
POTRERO POINT
LEGEND
EXISTING CHANNEL
RICHMOND HARBOR
WESTERLY CURRENTS

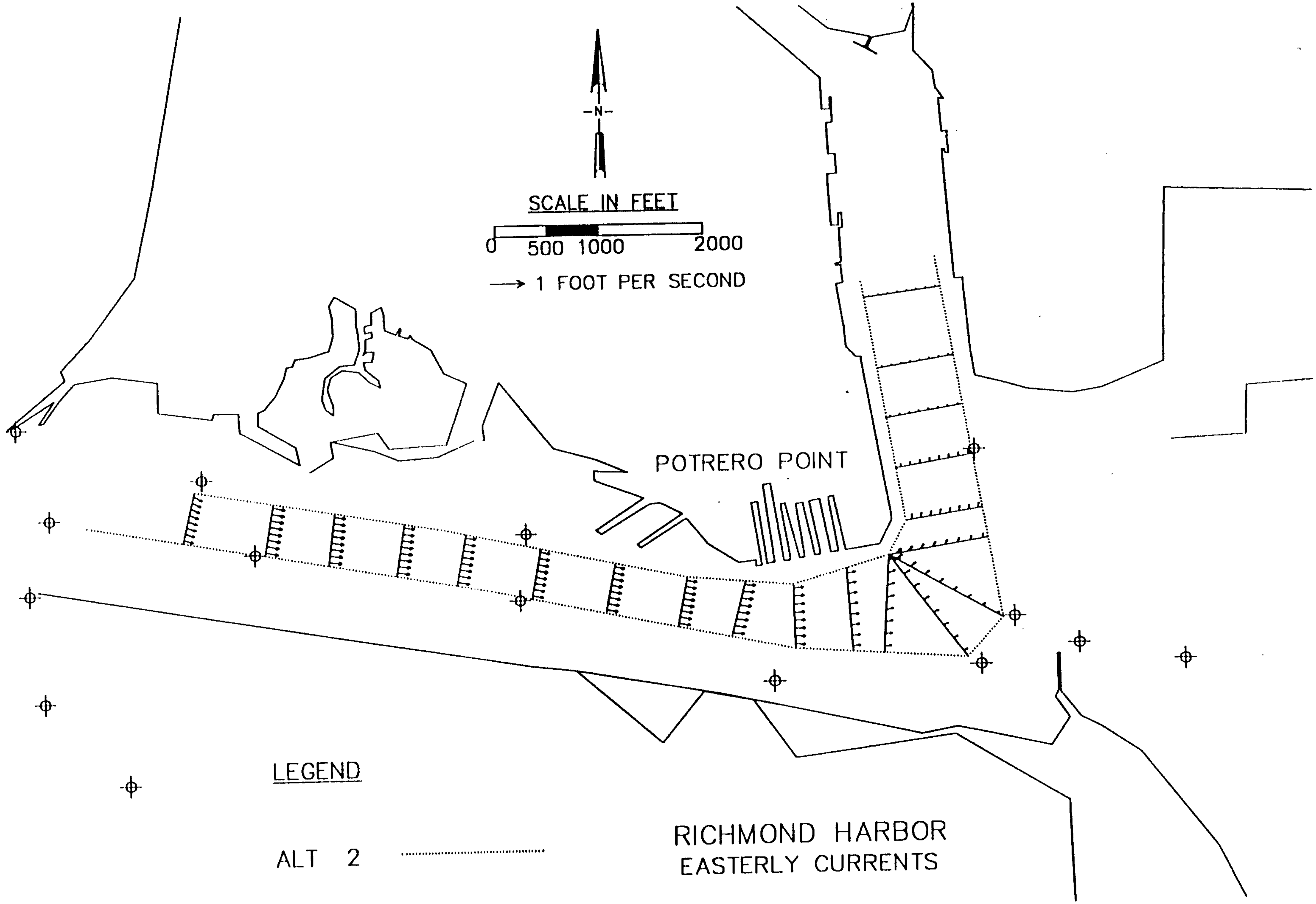
FIGURE


N
SCALE IN FEET
0
500
1000
2000
1 FOOT PER SECOND
POTRERO POINT
LEGEND
ALT 1
RICHMOND HARBOR
EASTERLY CURRENTS

FIGURE


-N-
SCALE IN FEET
0
500 1000
2000
1 FOOT PER SECOND
POTRERO POINT
LEGEND
ALT 1
RICHMOND HARBOR
WESTERLY CURRENTS

FIGURE


N
SCALE IN FEET
0 500 1000 2000
1 FOOT PER SECOND
POTRERO POINT
LEGEND
ALT 2
RICHMOND HARBOR
EASTERLY CURRENTS

FIGURE

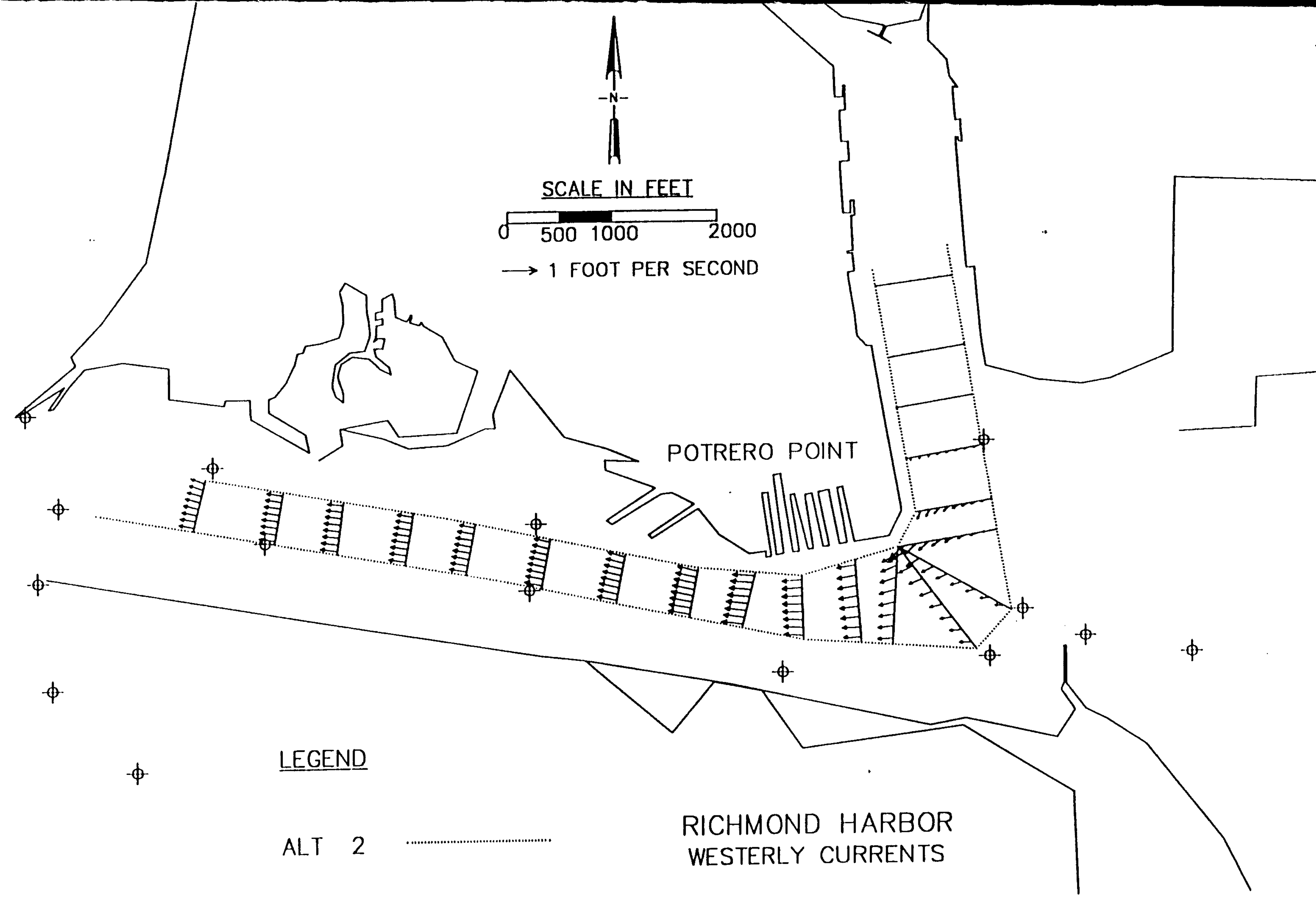
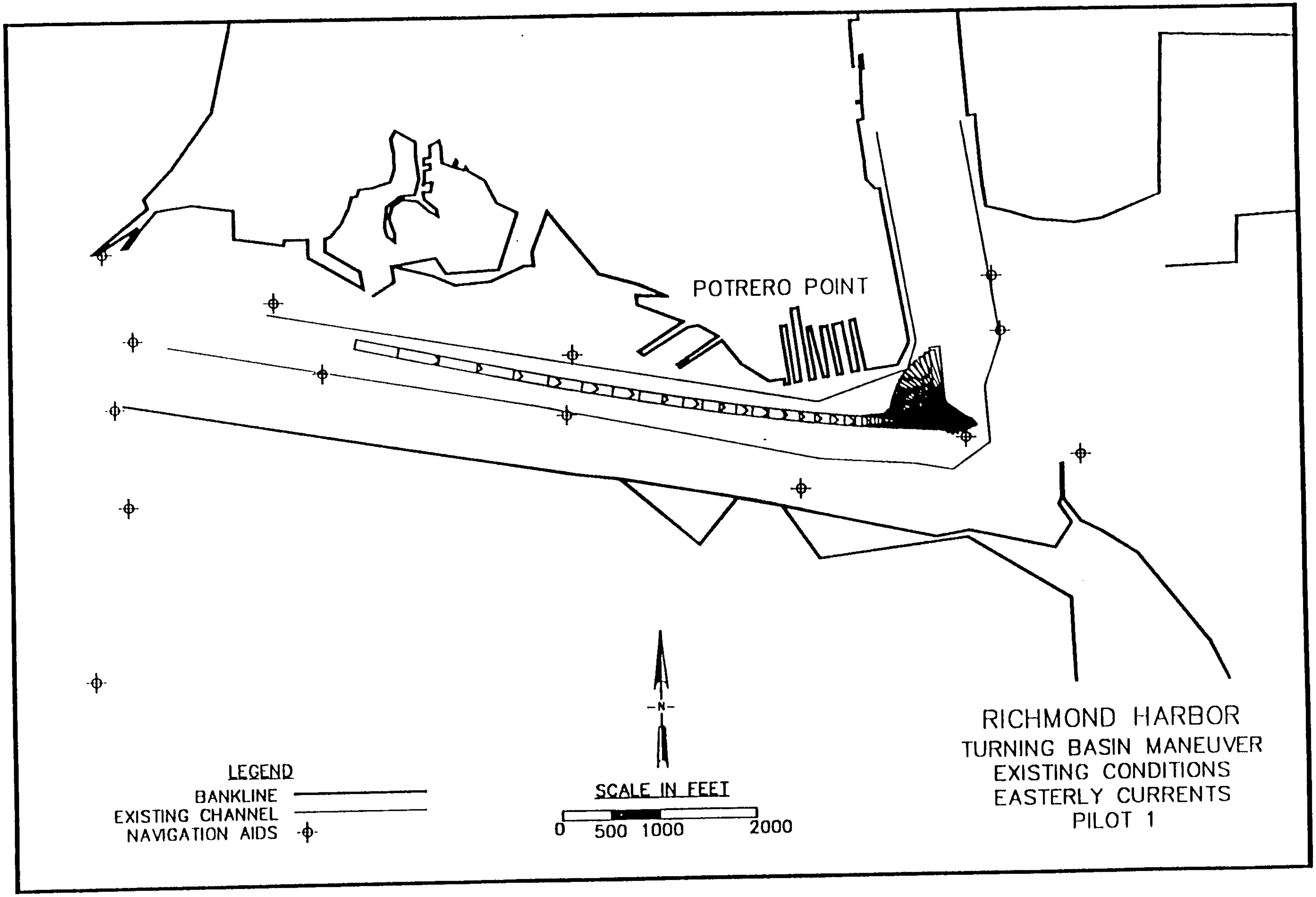

-N-
SCALE IN FEET
0 500 1000 2000
1 FOOT PER SECOND
POTRERO POINT
LEGEND
ALT 2
RICHMOND HARBOR
WESTERLY CURRENTS

FIGURE 1


POTRERO POINT
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
N
SCALE IN FEET
0
500
1000
2000
RICHMOND HARBOR
TURNING BASIN MANEUVER
EXISTING CONDITIONS
EASTERLY CURRENTS
PILOT 1

FIGURE

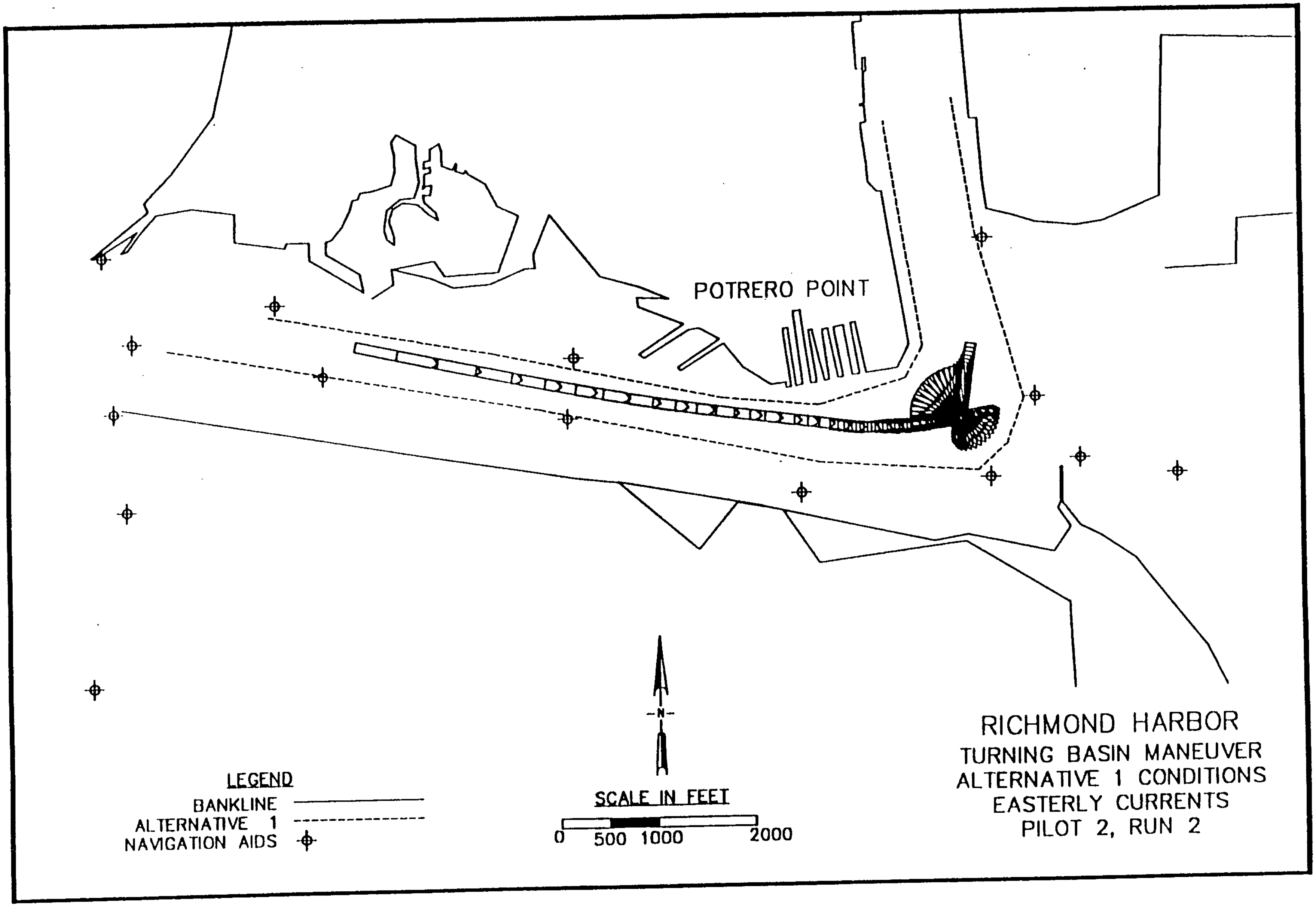
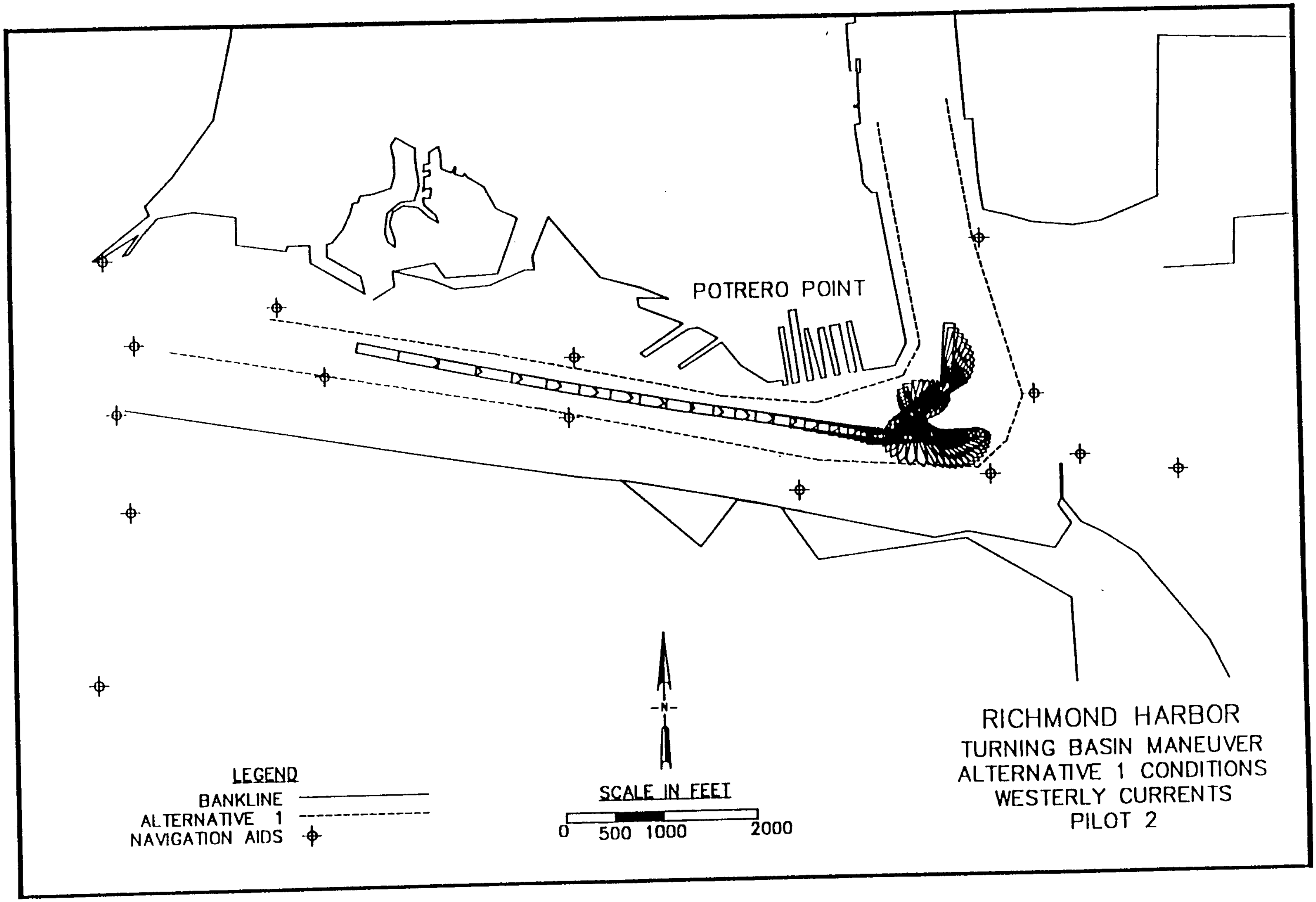
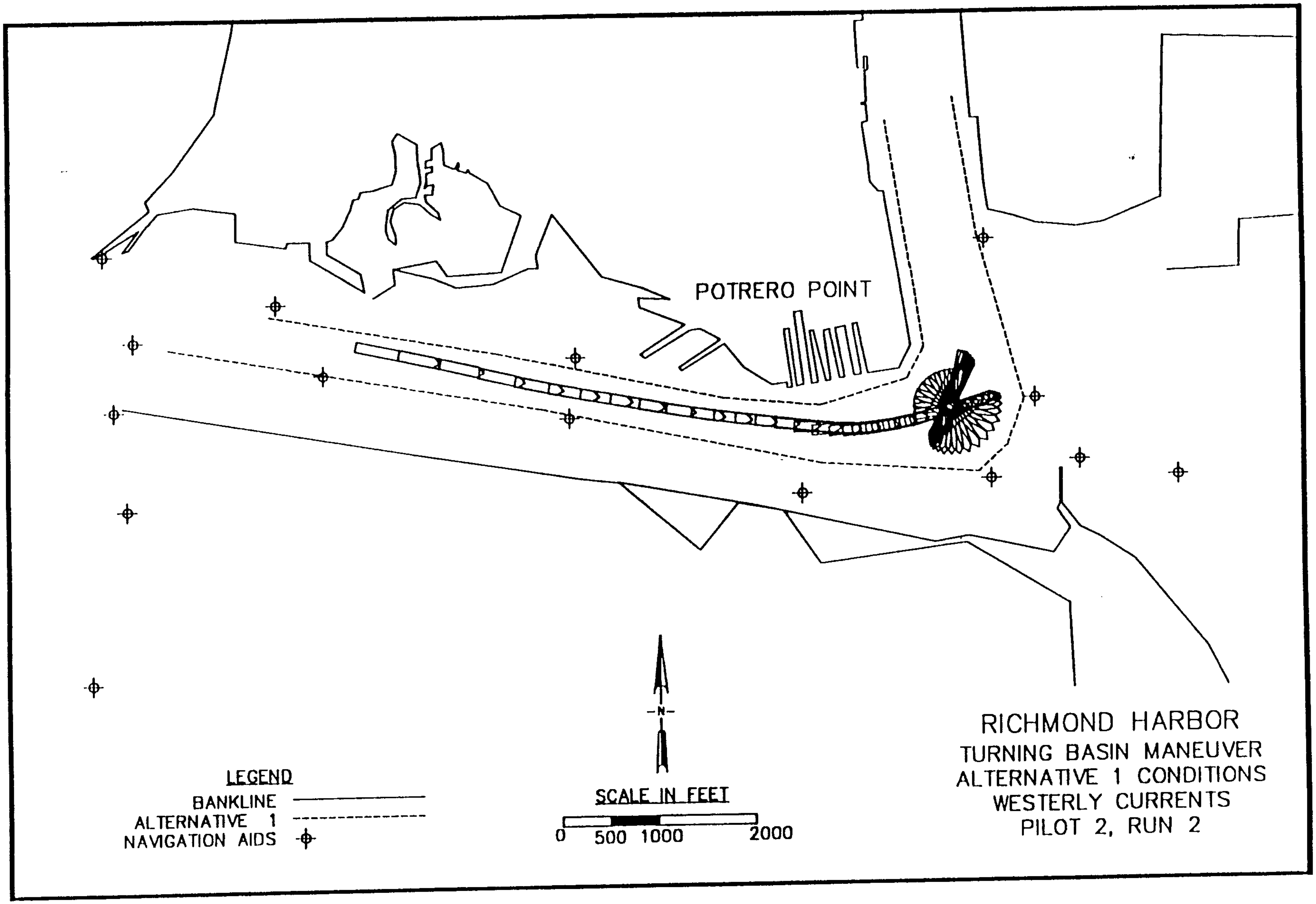

POTRERO POINT
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
N
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 1 CONDITIONS
EASTERLY CURRENTS
PILOT 2, RUN 2

FIGURE 2



RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 1 CONDITIONS
WESTERLY CURRENTS
PILOT 2

FIGC.P1


POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
SCALE IN FEET
0
500
1000
2000
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 1 CONDITIONS
WESTERLY CURRENTS
PILOT 2, RUN 2

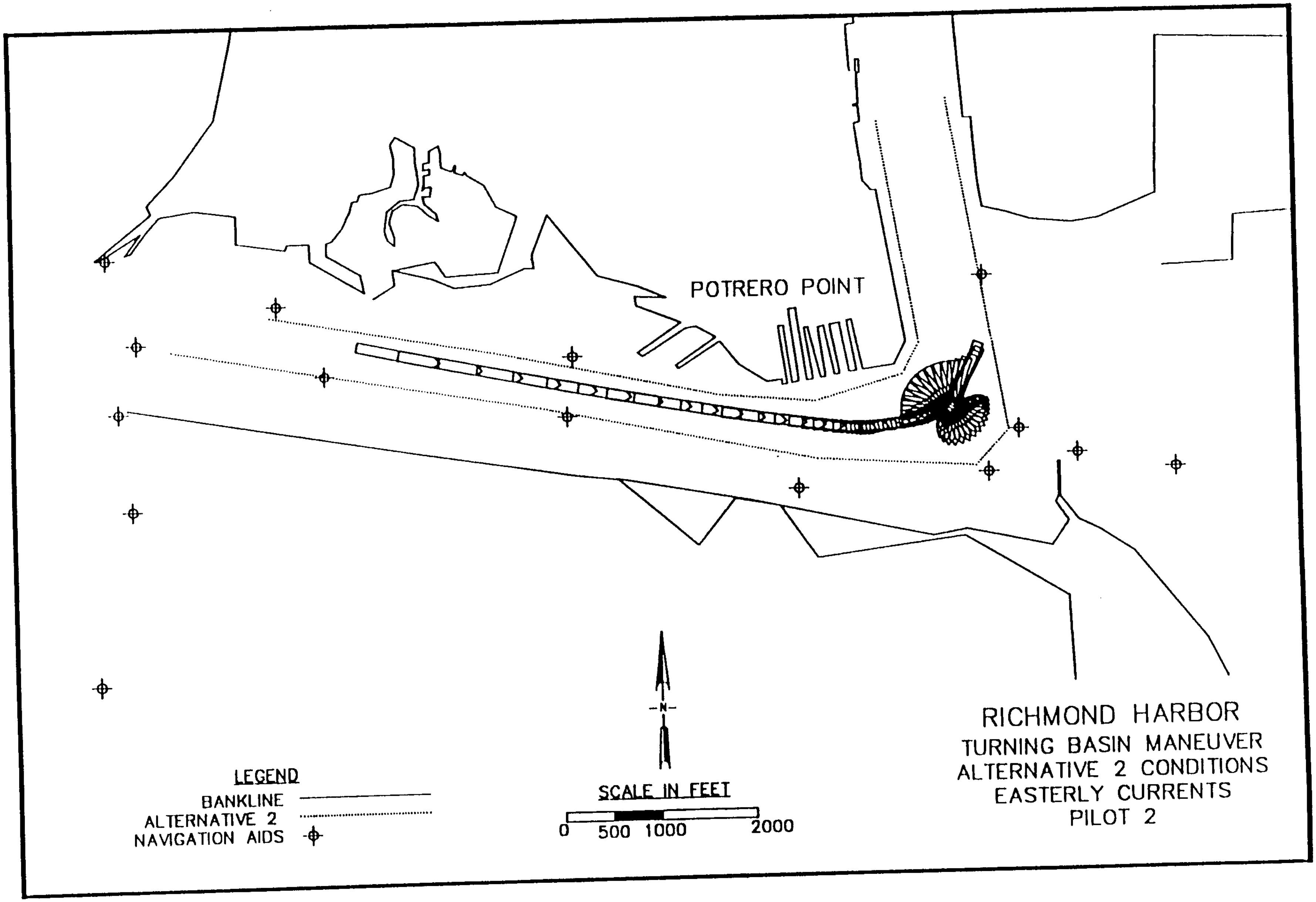

POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 2 CONDITIONS
EASTERLY CURRENTS
PILOT 2

FIGURE 2

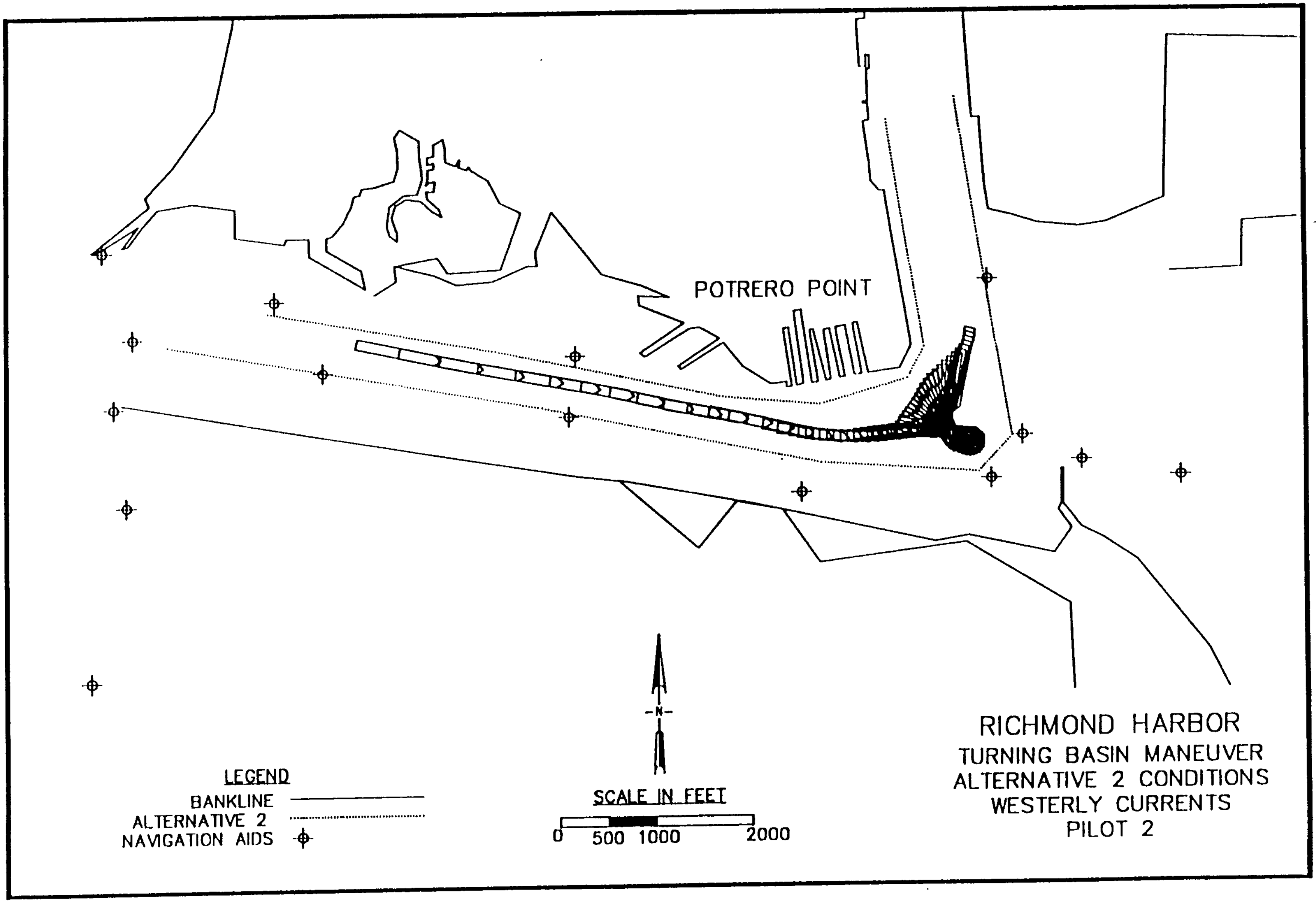
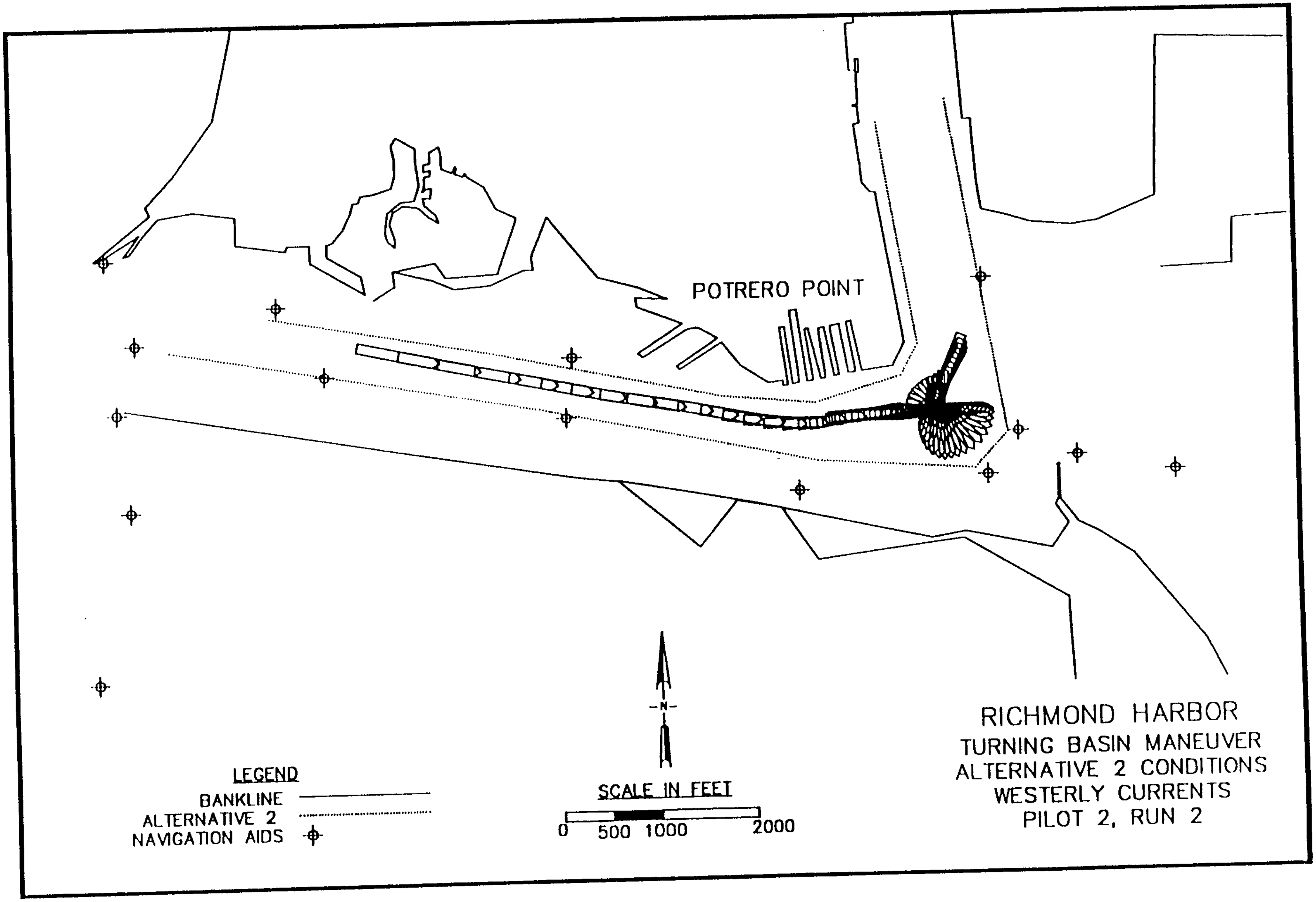
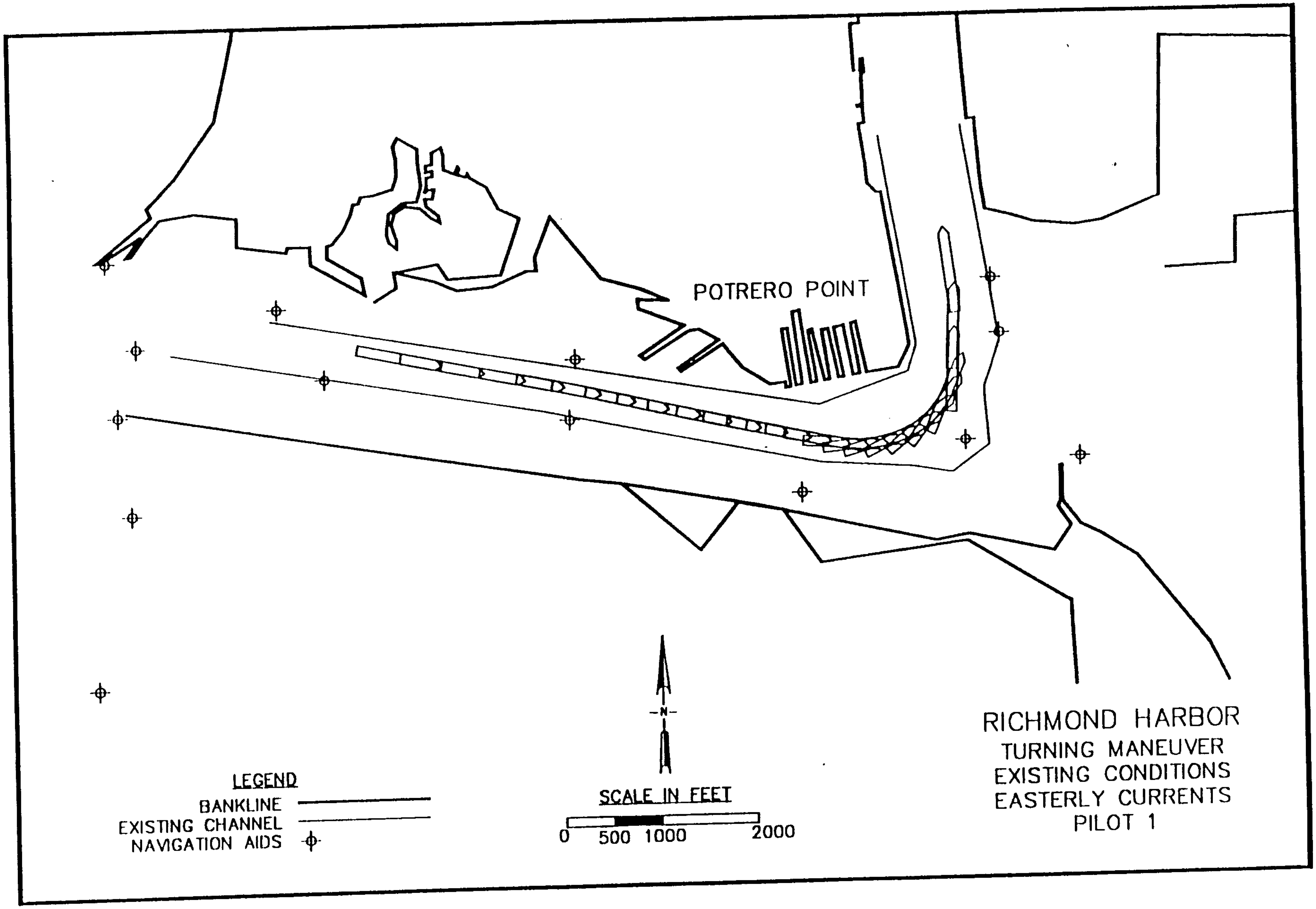

POTRERO POINT
-N-
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 2 CONDITIONS
WESTERLY CURRENTS
PILOT 2

FIGURE 3?


RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 2 CONDITIONS
WESTERLY CURRENTS
PILOT 2, RUN 2
POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000

PIG.42E



POTRERO POINT
N
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
EXISTING CONDITIONS
EASTERLY CURRENTS
PILOT 1

FIGURE 29

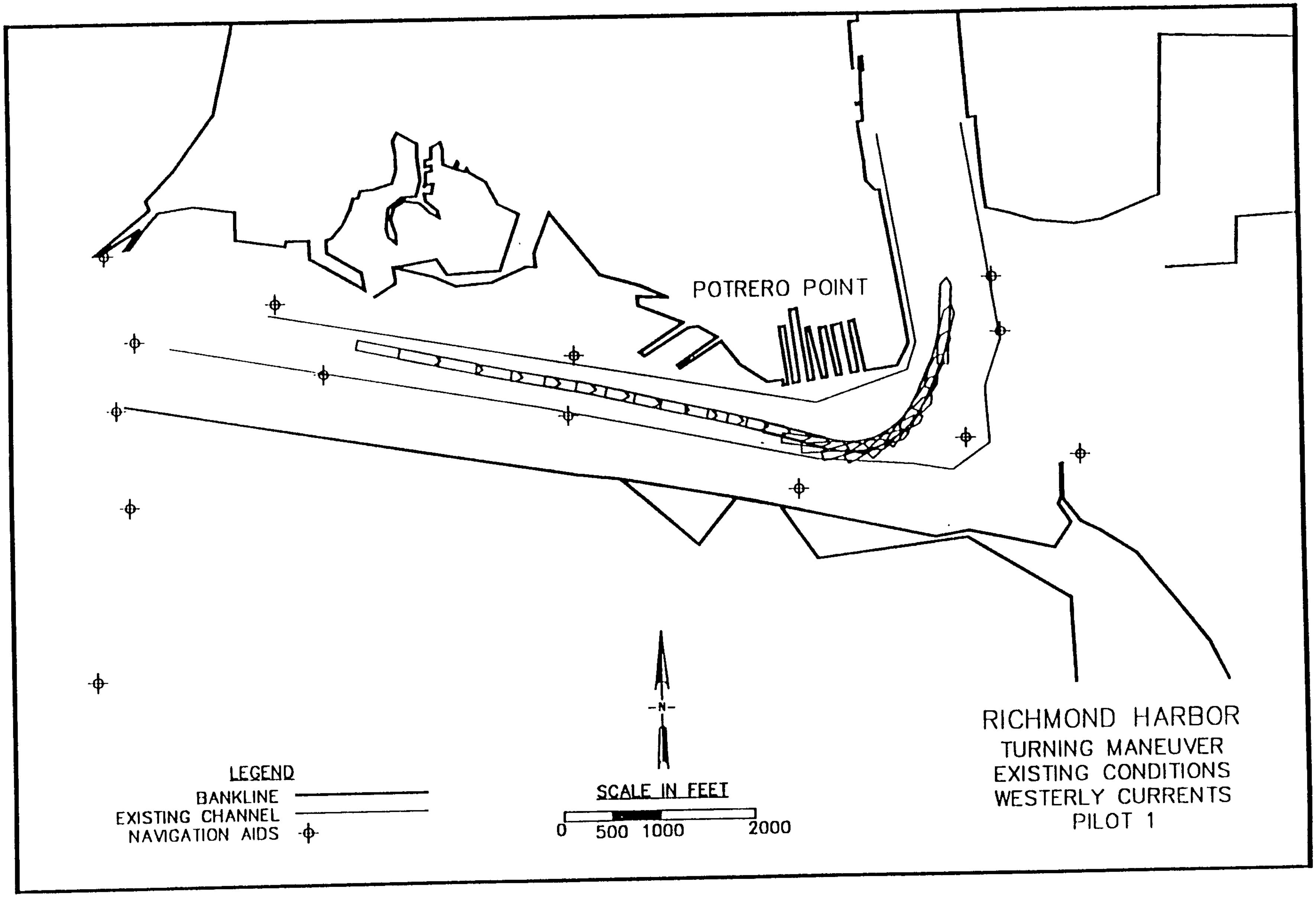
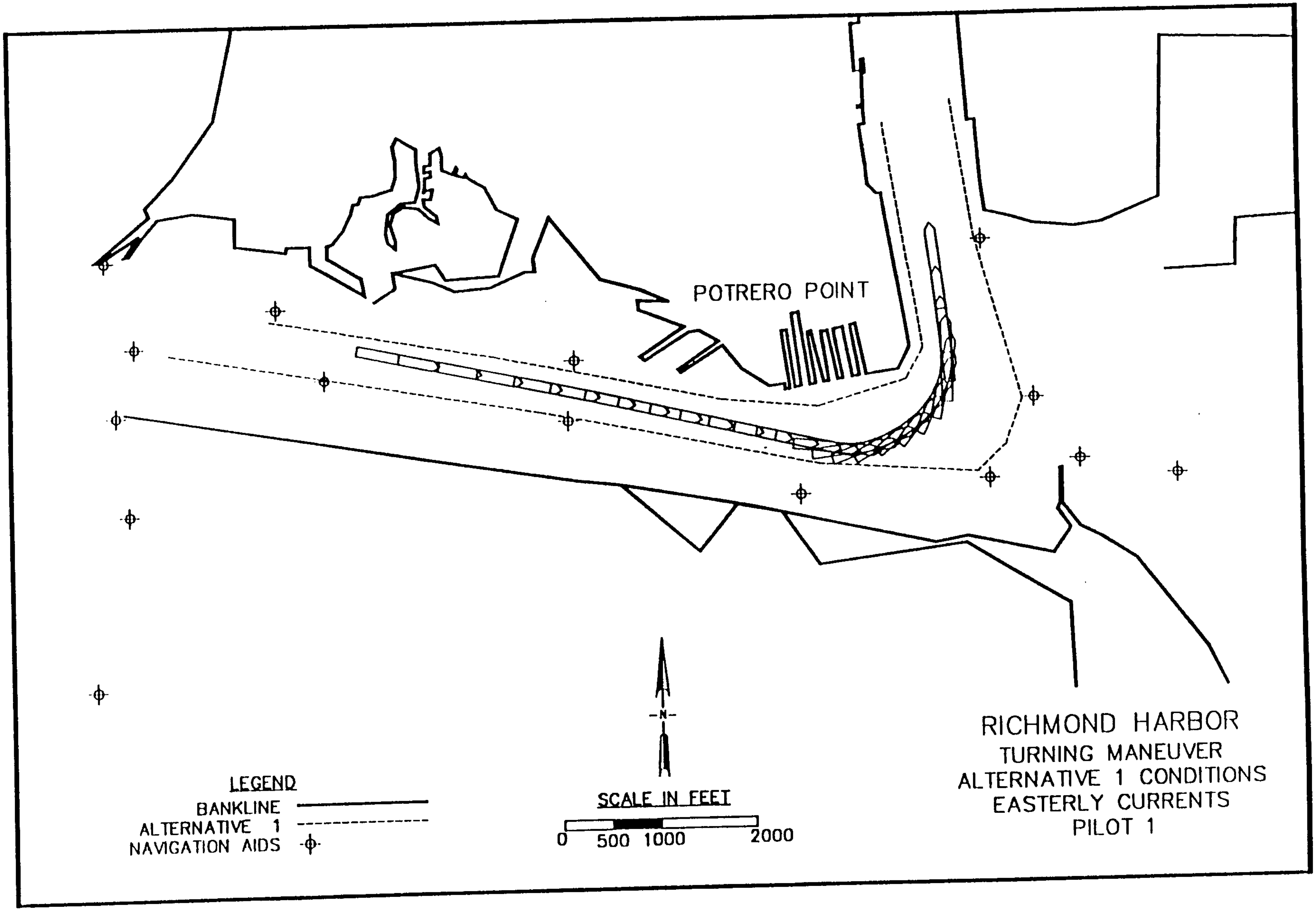
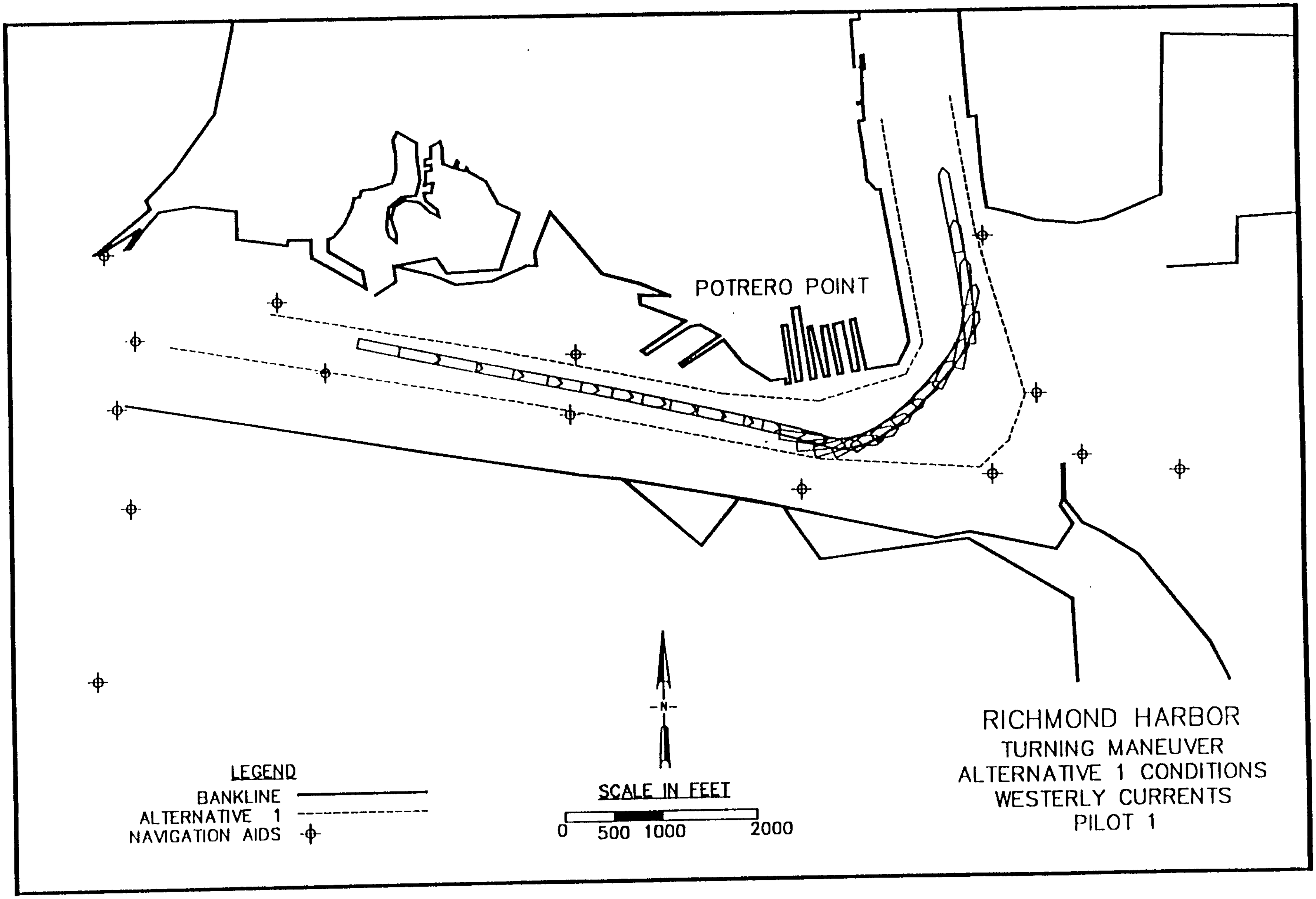

POTRERO POINT
RICHMOND HARBOR
TURNING MANEUVER
EXISTING CONDITIONS
WESTERLY CURRENTS
PILOT 1
N
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000

FIGURE 3



POTRERO POINT
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
N
SCALE IN FEET
0
500
1000
2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 1 CONDITIONS
EASTERLY CURRENTS
PILOT 1

FIGURE 31


POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 1 CONDITIONS
WESTERLY CURRENTS
PILOT 1

FIGURE

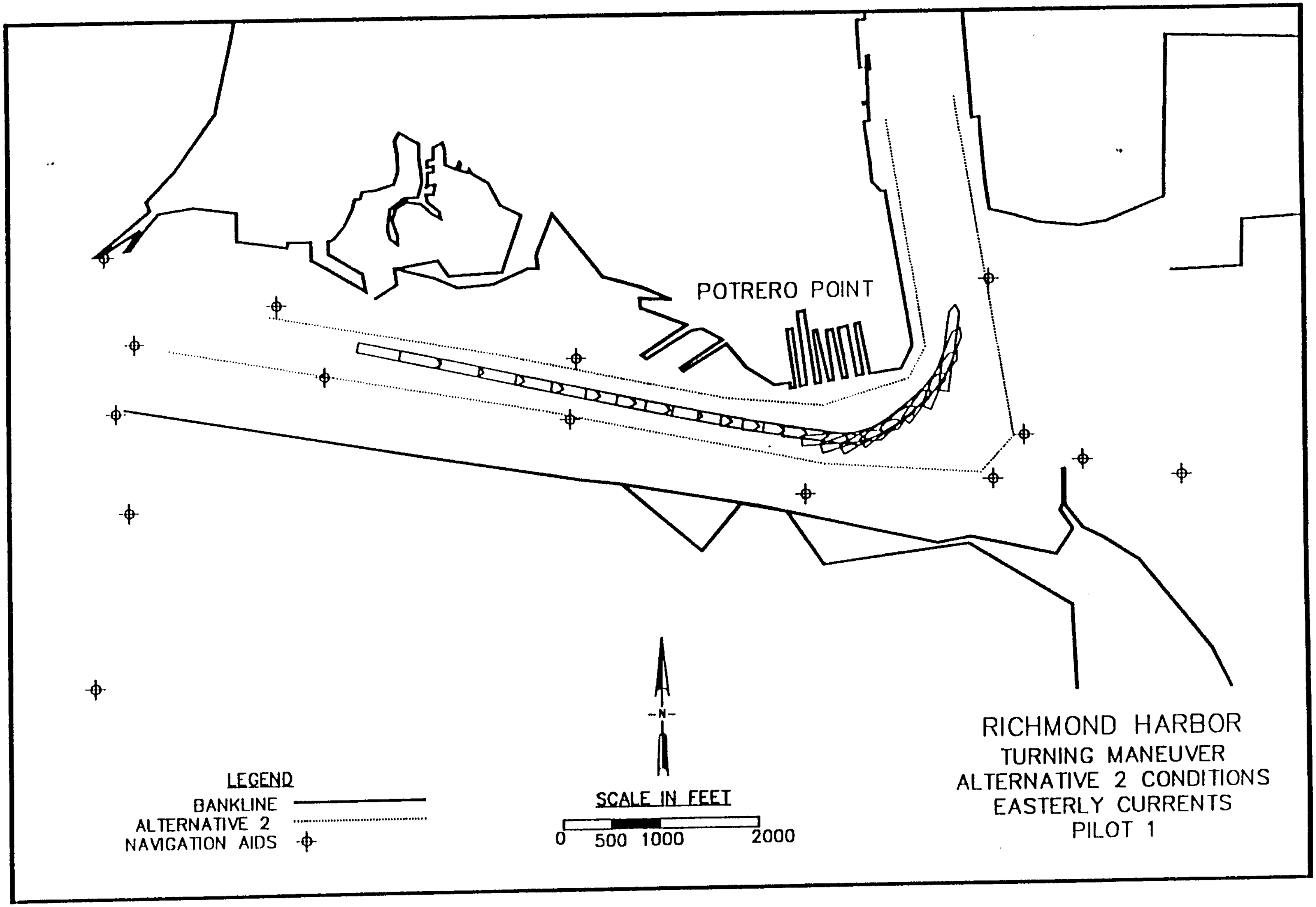

POTRERO POINT
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
-N-
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 2 CONDITIONS
EASTERLY CURRENTS
PILOT 1

FIGURE 5.

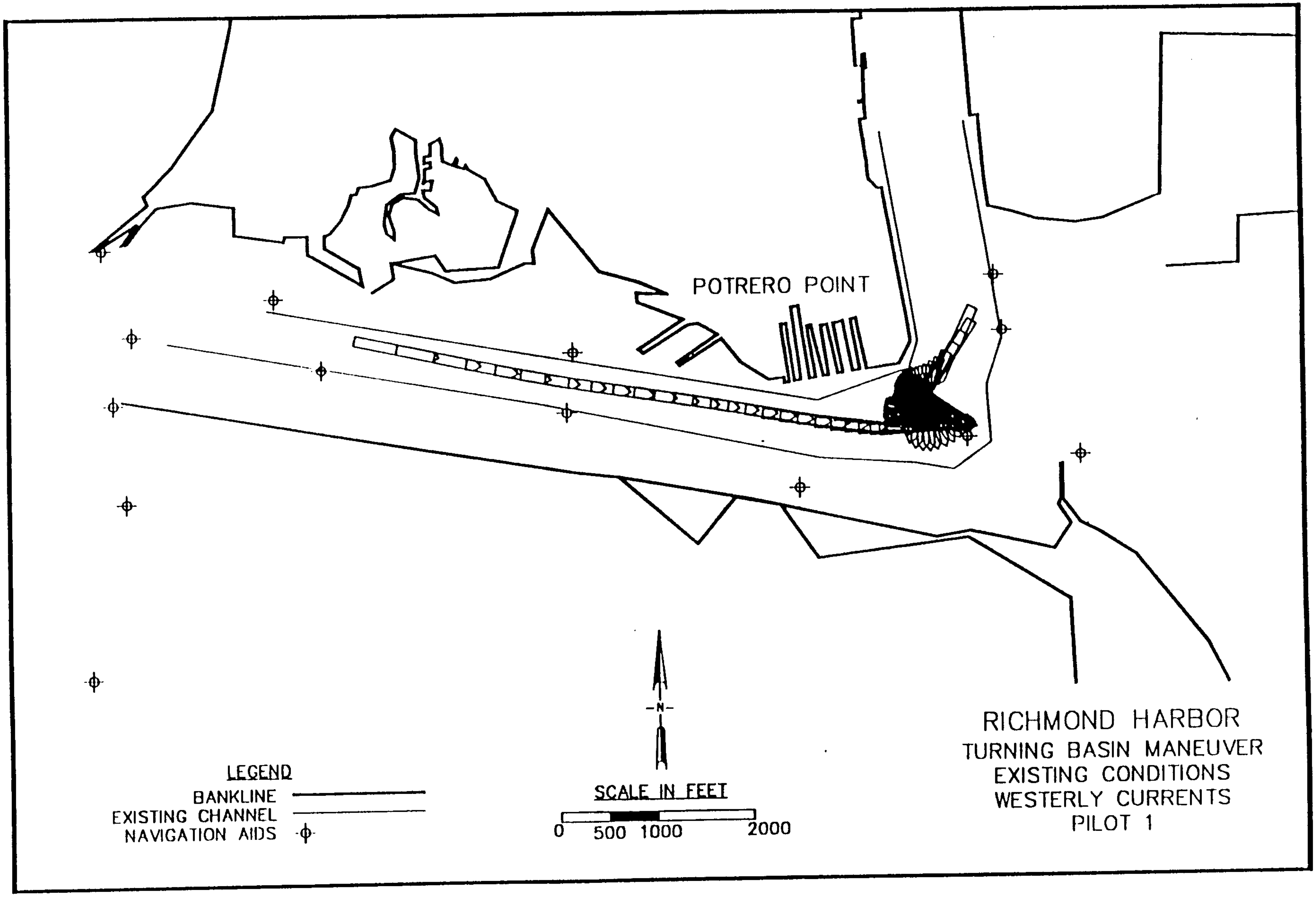
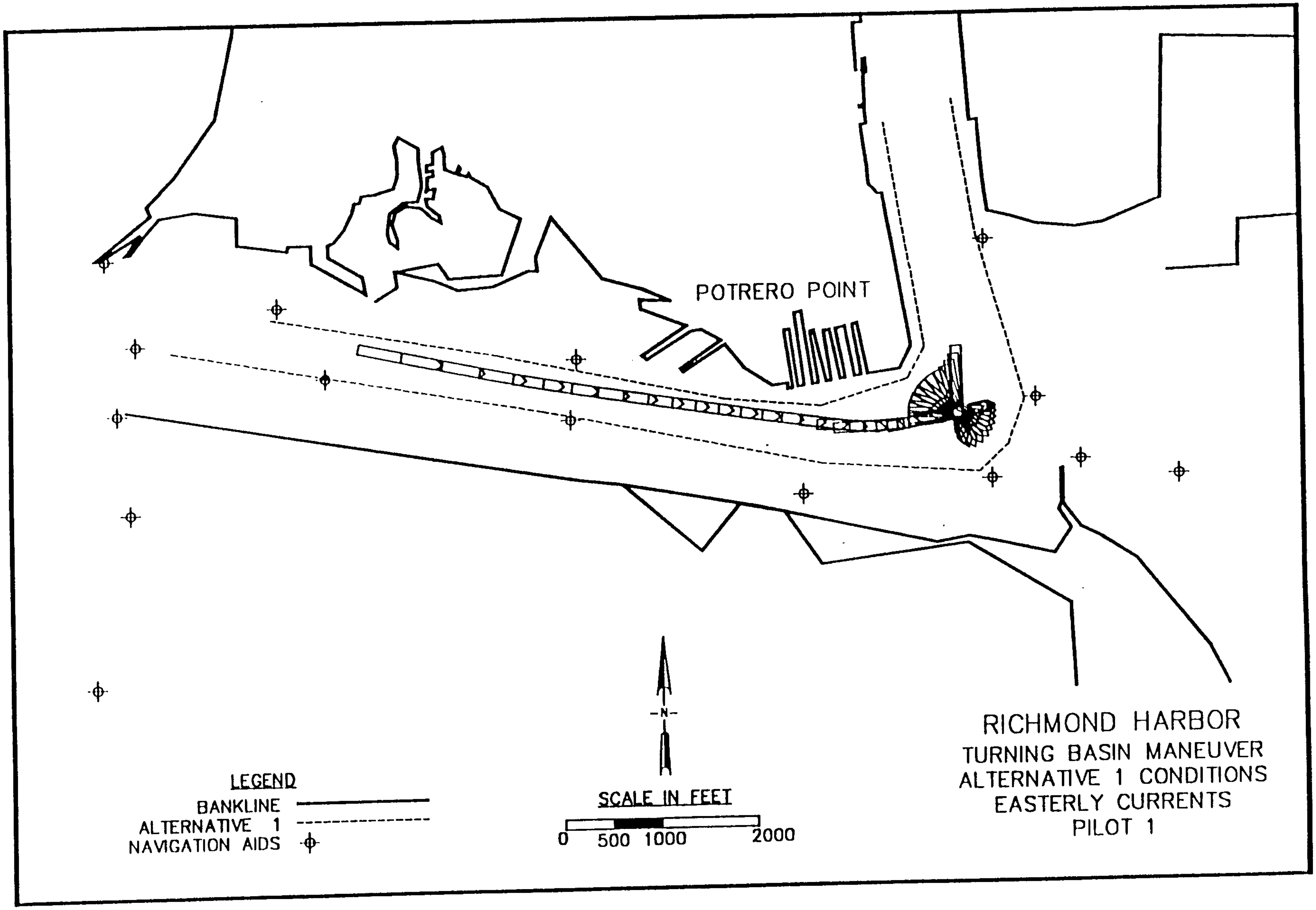
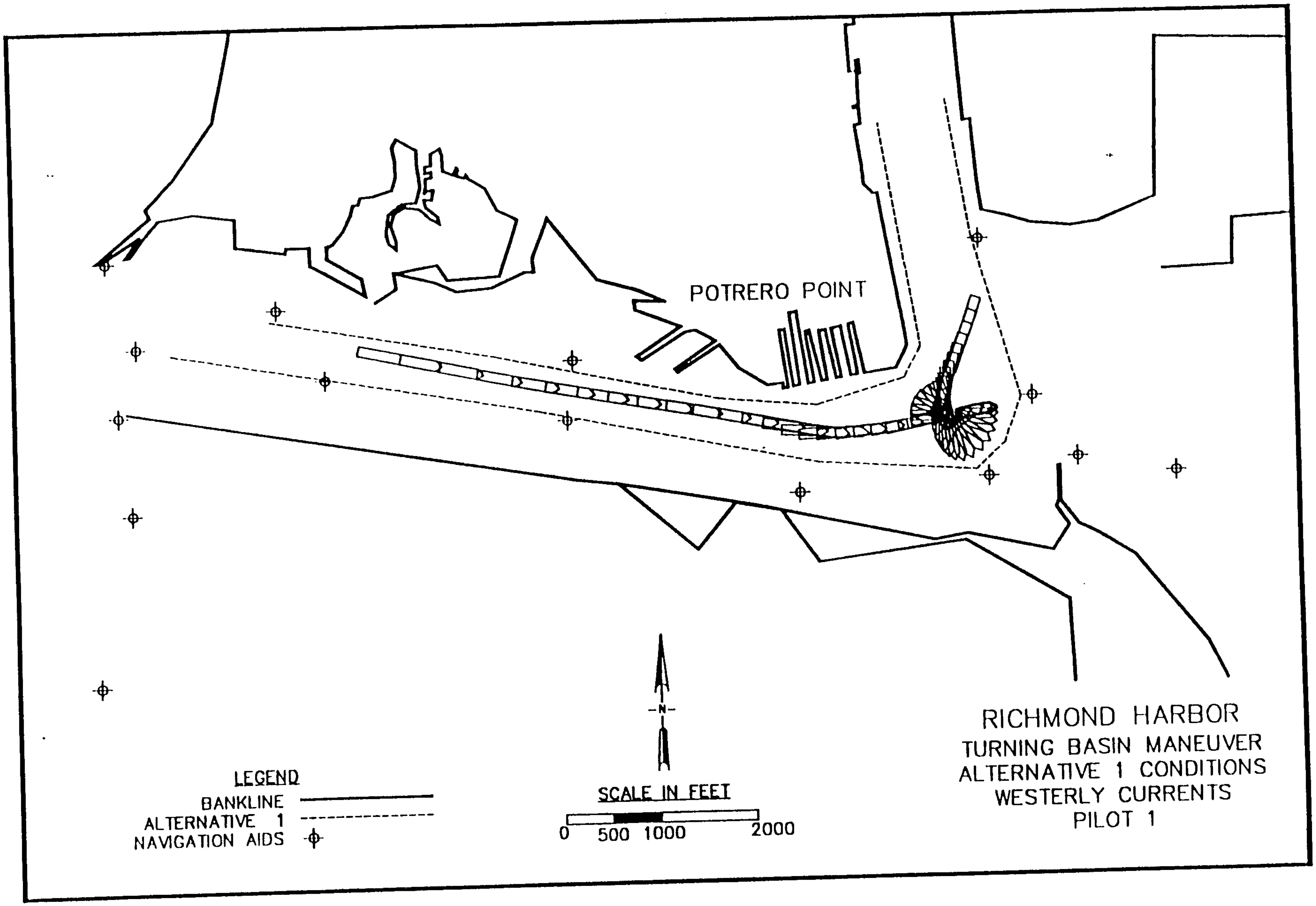

POTRERO POINT
RICHMOND HARBOR
TURNING BASIN MANEUVER
EXISTING CONDITIONS
WESTERLY CURRENTS
PILOT 1
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
N

FIGURE 1



POTRERO POINT
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
N
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 1 CONDITIONS
EASTERLY CURRENTS
PILOT 1

FIGURE 1


POTRERO POINT
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 1 CONDITIONS
WESTERLY CURRENTS
PILOT 1
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
N

FIGURE

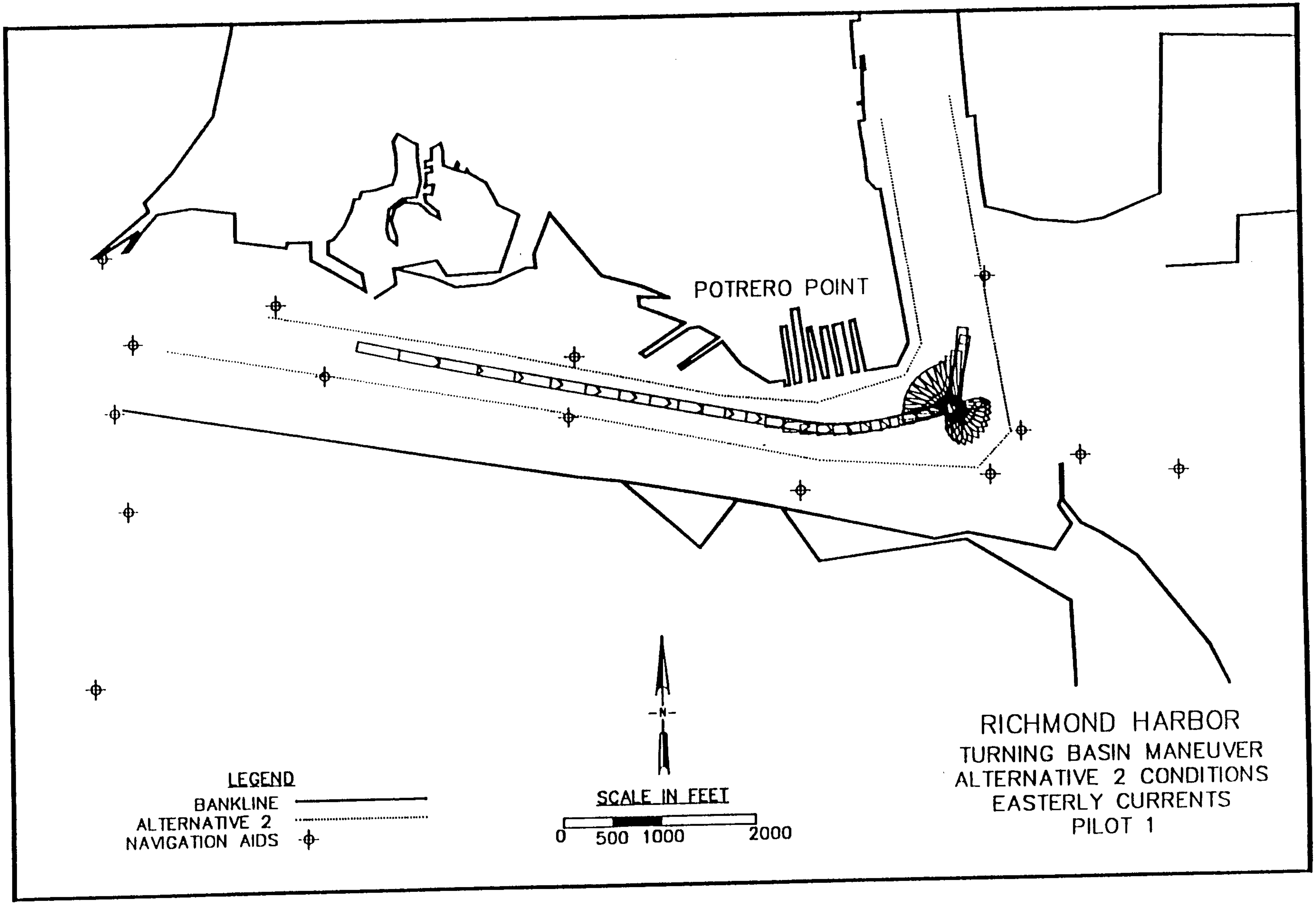

POTRERO POINT
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 2 CONDITIONS
EASTERLY CURRENTS
PILOT 1
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
N

FIGURE 18

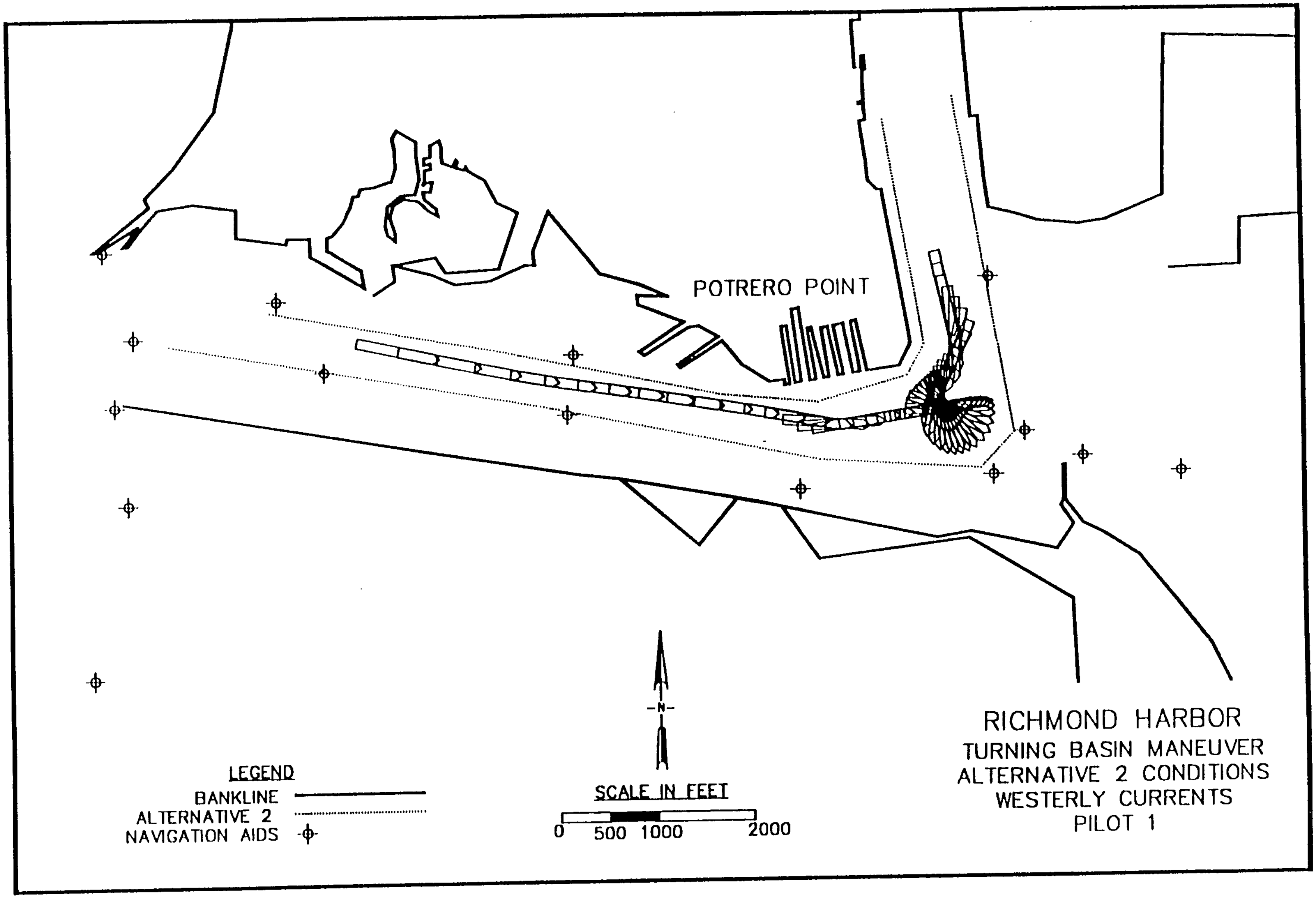

POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 2 CONDITIONS
WESTERLY CURRENTS
PILOT 1

FIGURE 1

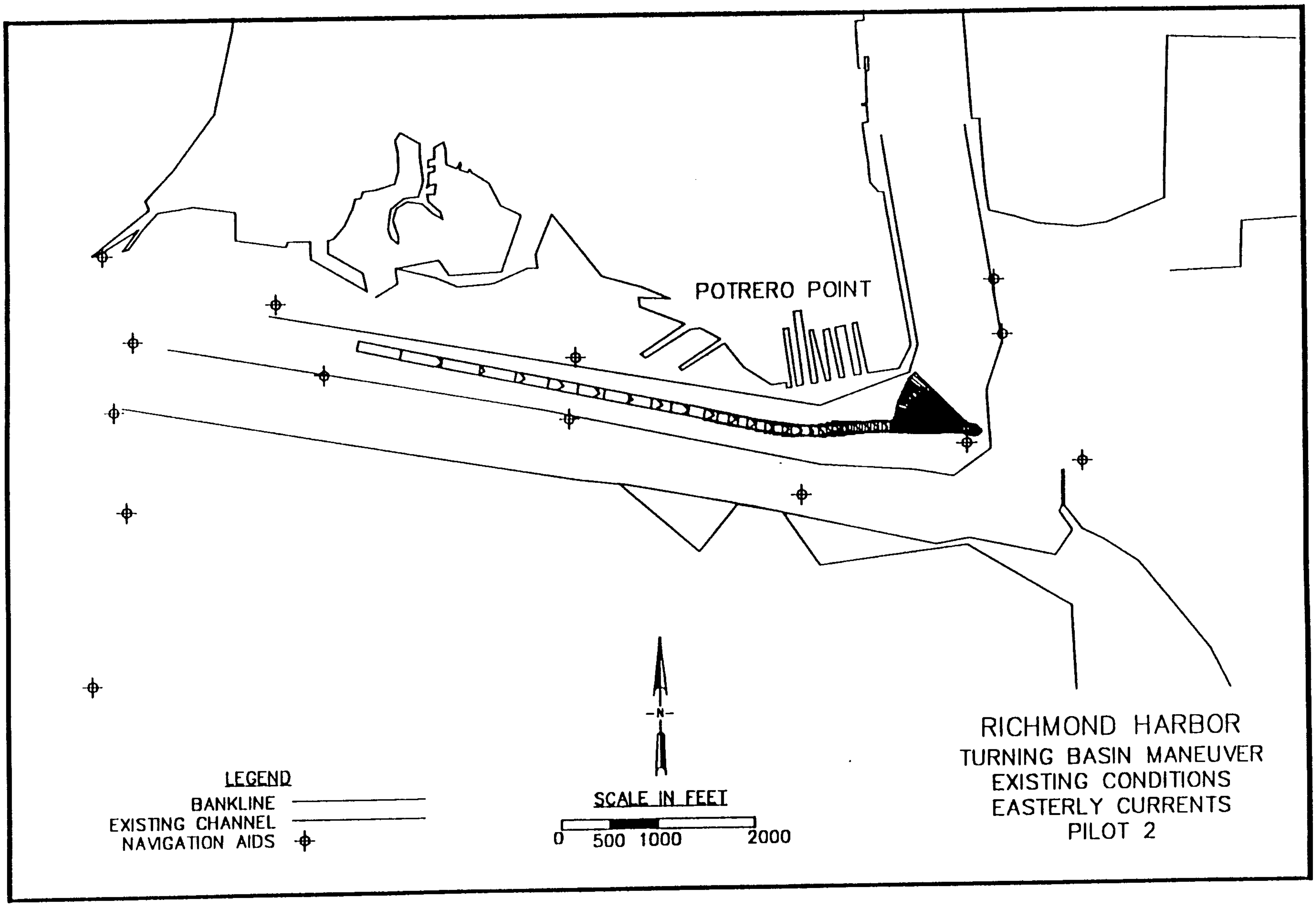

POTRERO POINT
RICHMOND HARBOR
TURNING BASIN MANEUVER
EXISTING CONDITIONS
EASTERLY CURRENTS
PILOT 2
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
N

FIGURE 2

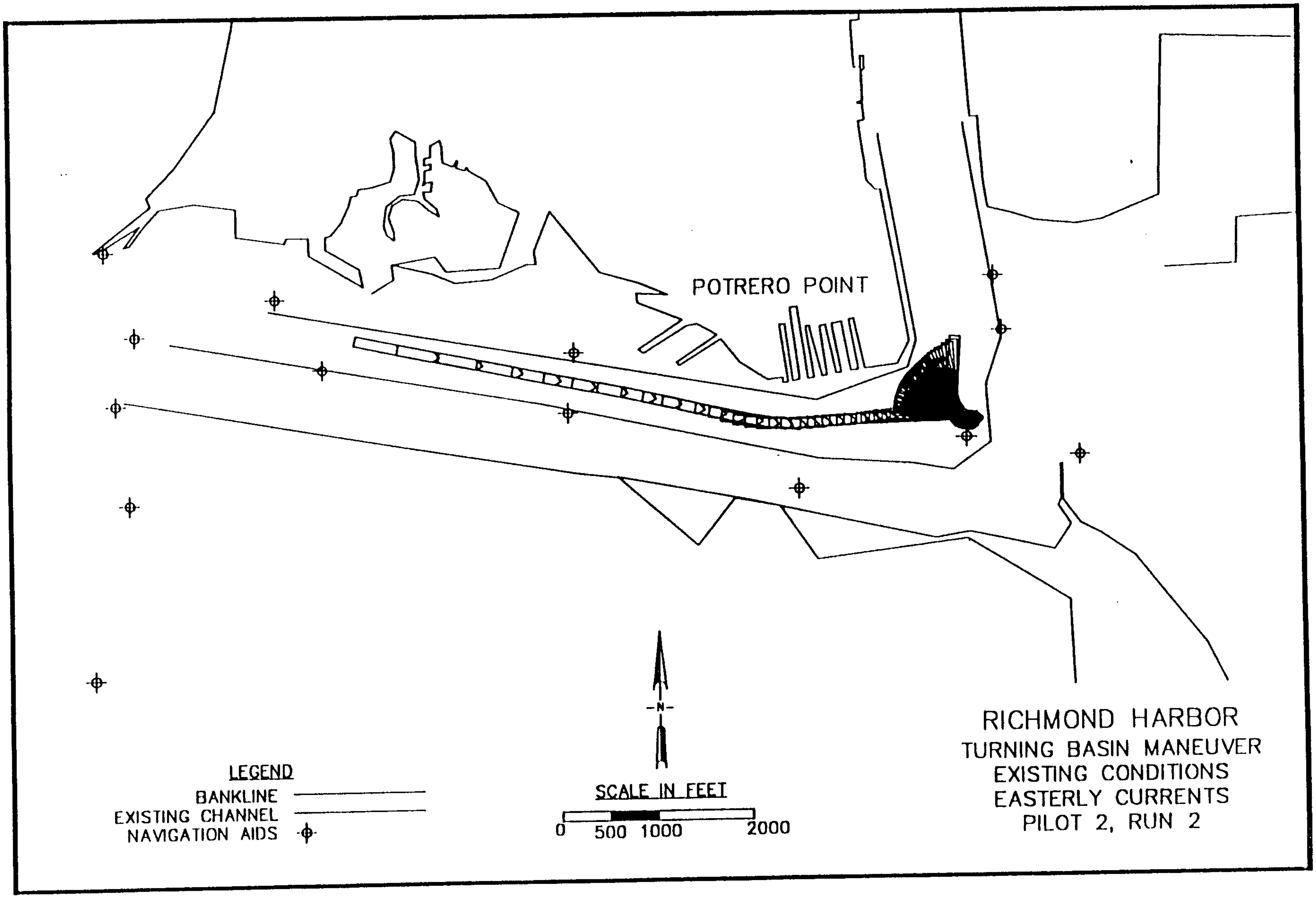

POTRERO POINT
RICHMOND HARBOR
TURNING BASIN MANEUVER
EXISTING CONDITIONS
EASTERLY CURRENTS
PILOT 2, RUN 2
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
SCALE IN FEET
0
500
1000
2000
N

FIGURE 2

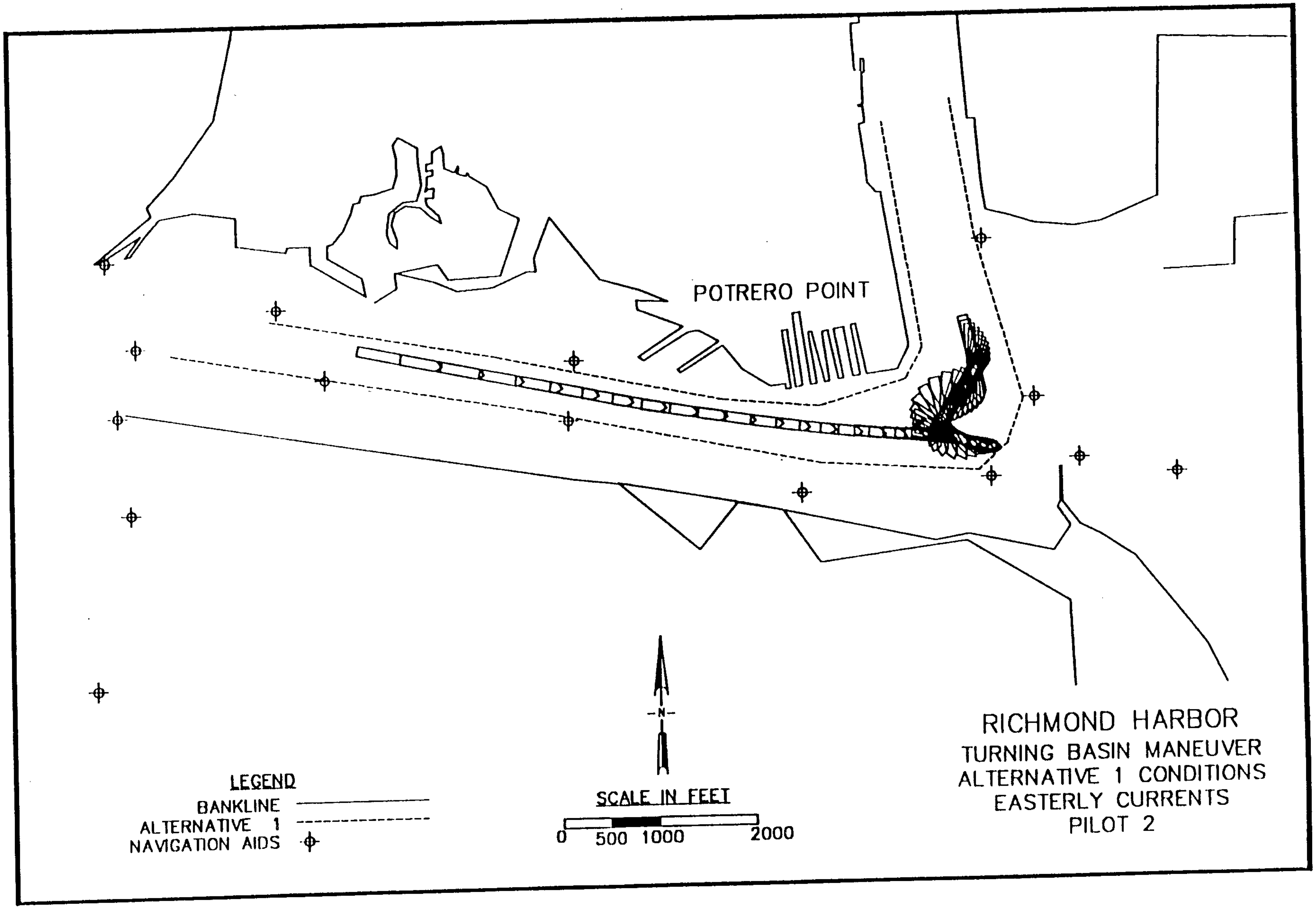
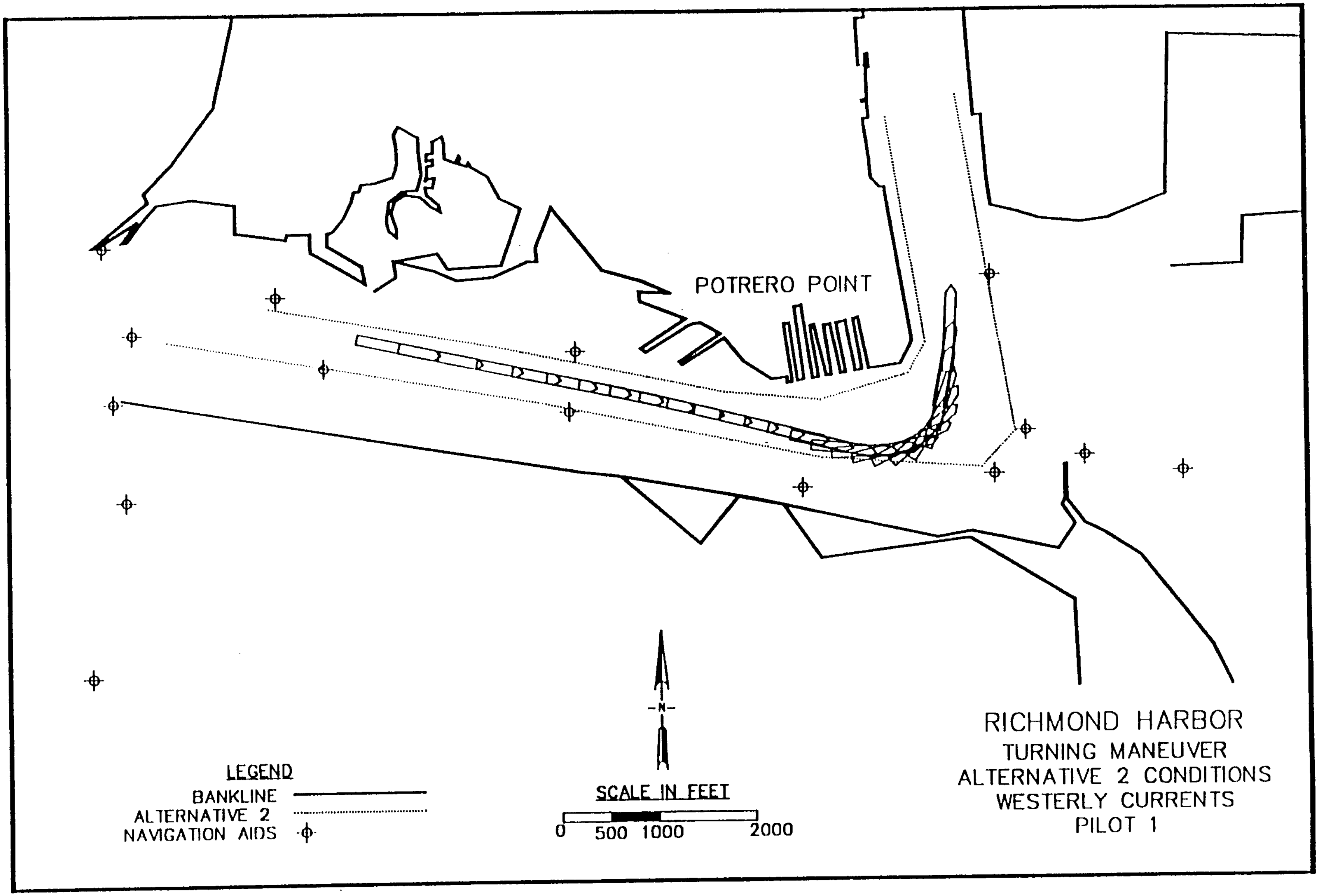

POTRERO POINT
RICHMOND HARBOR
TURNING BASIN MANEUVER
ALTERNATIVE 1 CONDITIONS
EASTERLY CURRENTS
PILOT 2
N
SCALE IN FEET
0 500 1000 2000
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS

FIGURE 2



POTRERO POINT
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
N
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 2 CONDITIONS
WESTERLY CURRENTS
PILOT 1

FIGURE

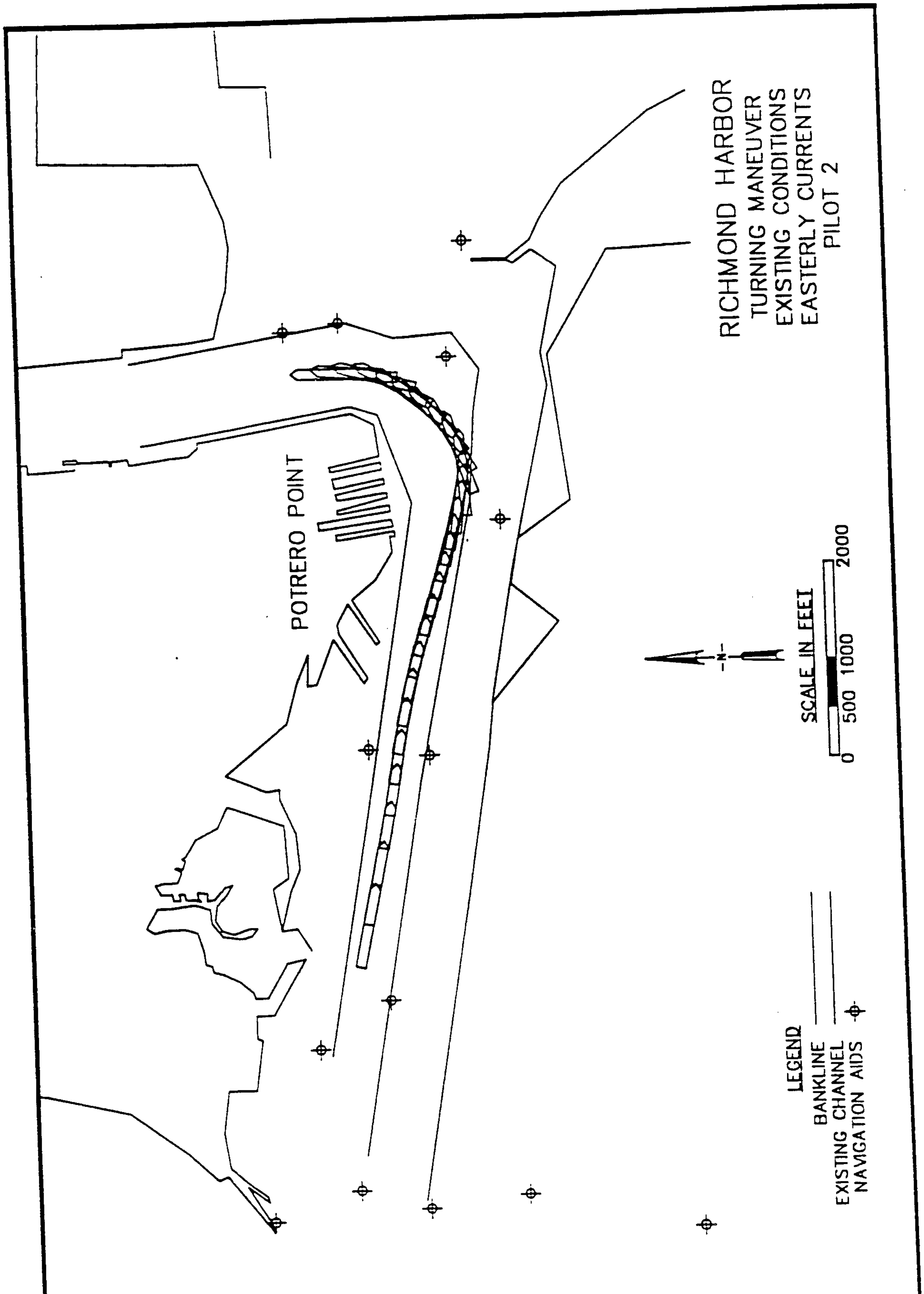
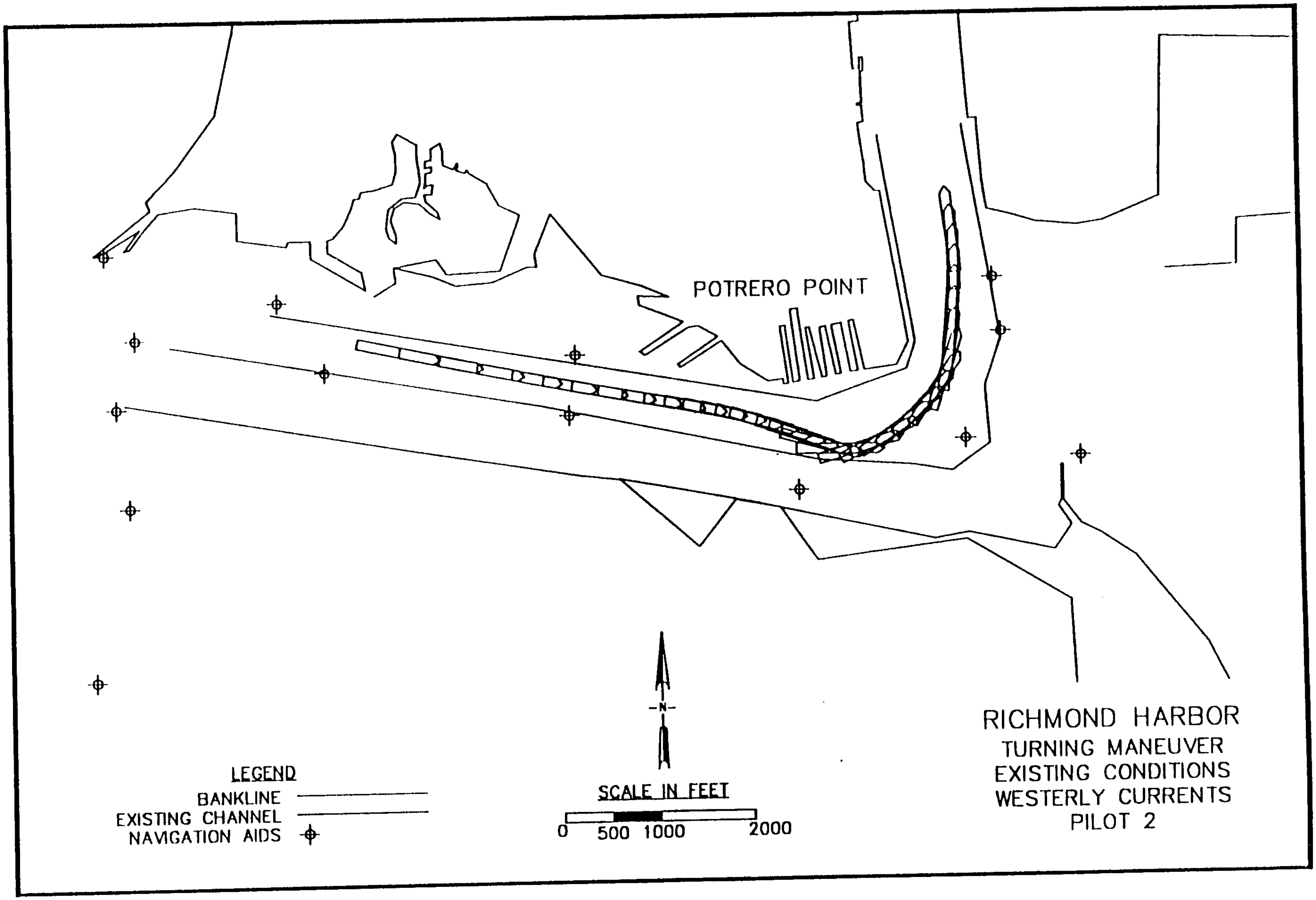

RICHMOND HARBOR
TURNING MANEUVER
EXISTING CONDITIONS
EASTERLY CURRENTS
PILOT 2
POTRERO POINT
N
SCALE IN FEET
0 500 1000 2000
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS

FIGURE 3



POTRERO POINT
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
N
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
EXISTING CONDITIONS
WESTERLY CURRENTS
PILOT 2

FIGURE 3

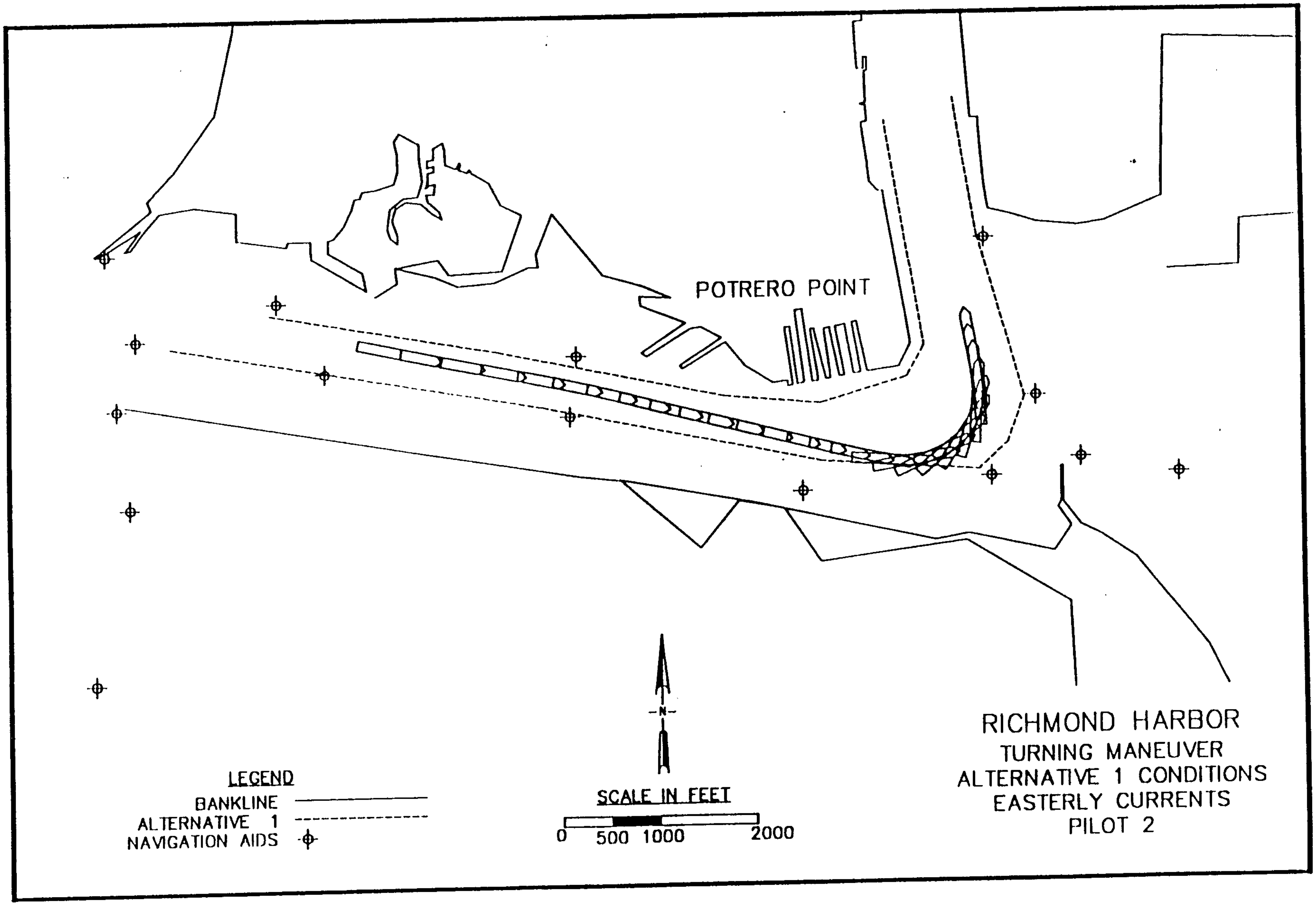

POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 1 CONDITIONS
EASTERLY CURRENTS
PILOT 2

FIGURE 3

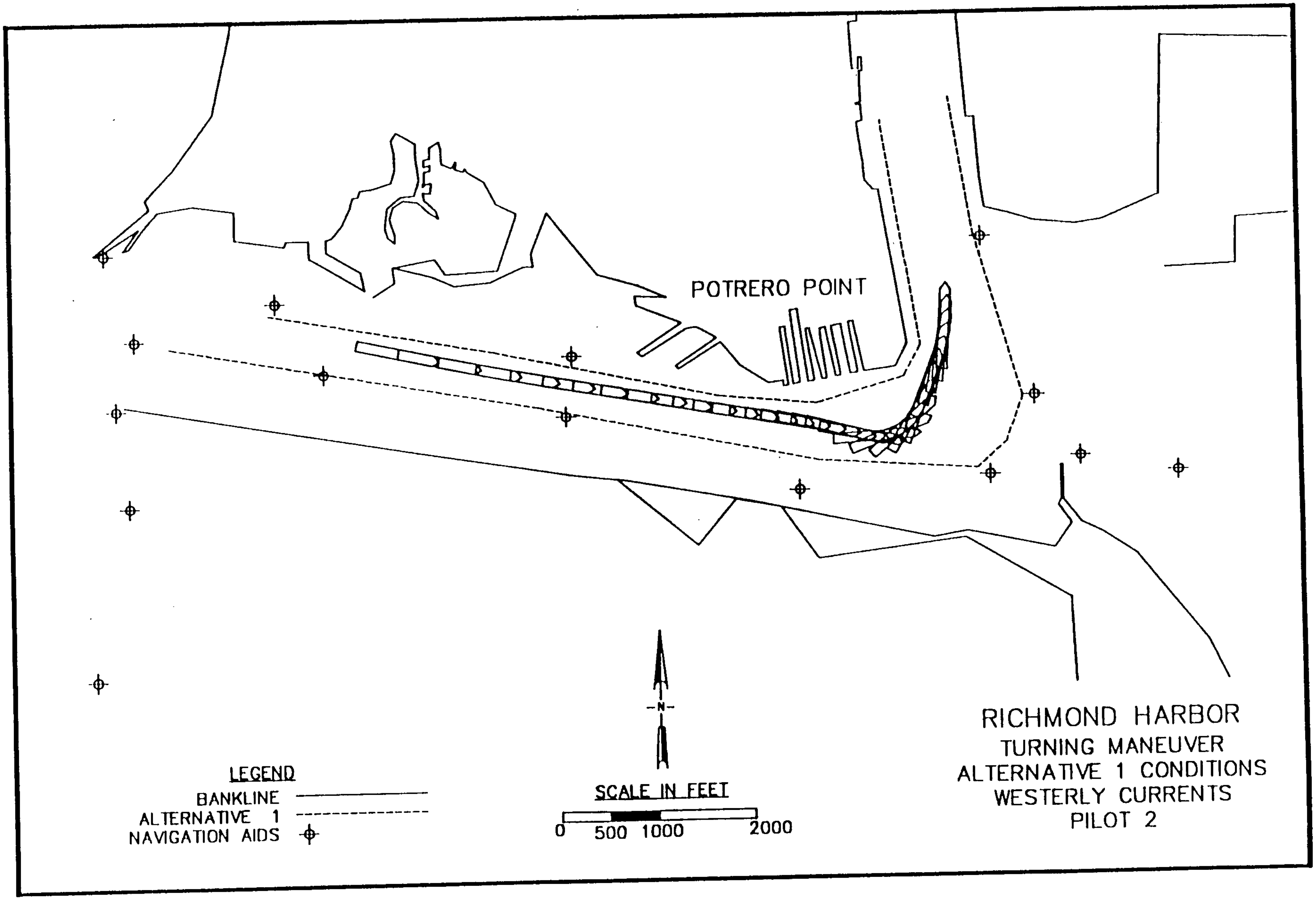

POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 1 CONDITIONS
WESTERLY CURRENTS
PILOT 2

FIGURE 3

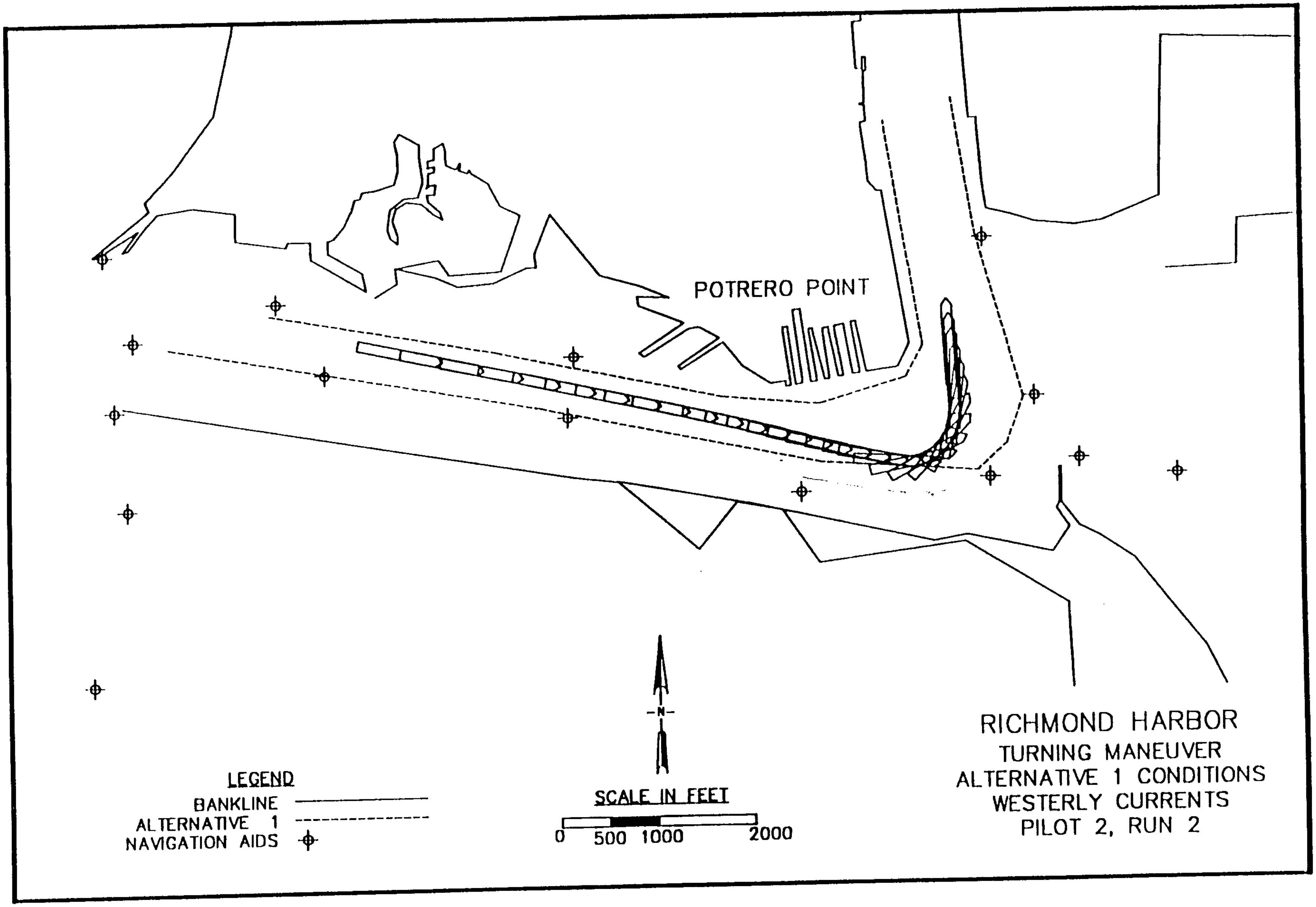
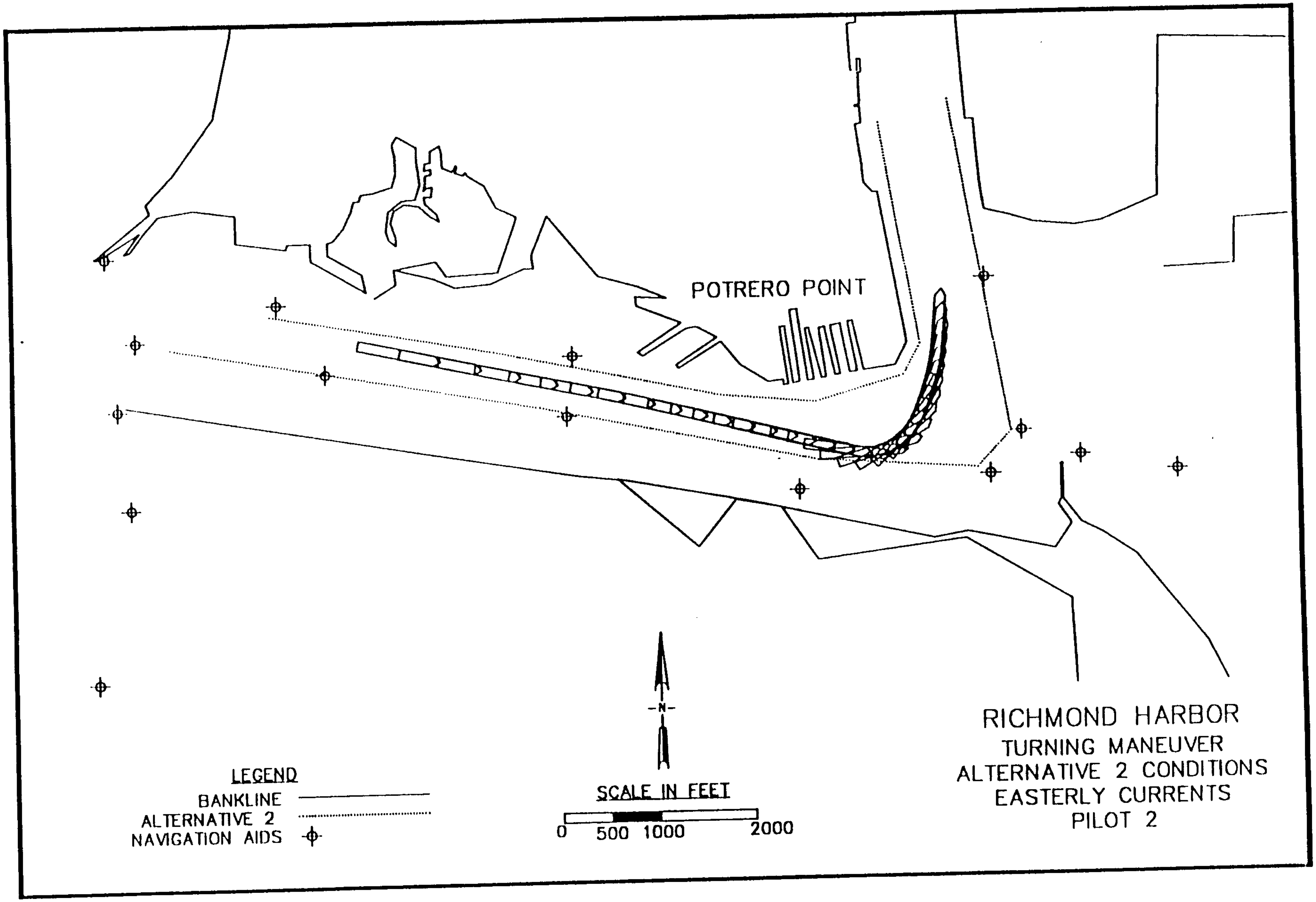

POTRERO POINT
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
N
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 1 CONDITIONS
WESTERLY CURRENTS
PILOT 2, RUN 2

FIGURE 1


POTRERO POINT
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
N
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 2 CONDITIONS
EASTERLY CURRENTS
PILOT 2

FIGURE

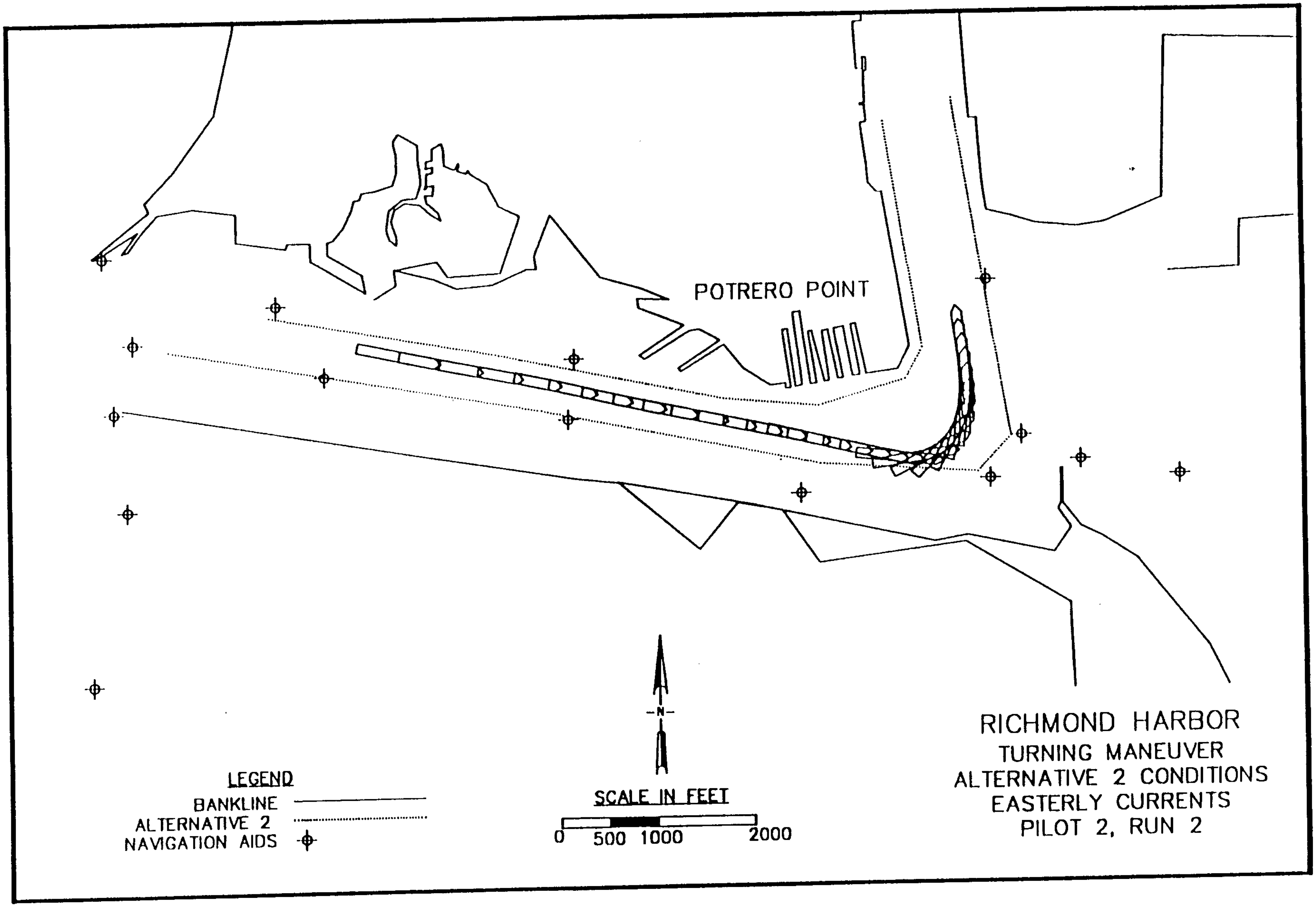

POTRERO POINT
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 2 CONDITIONS
EASTERLY CURRENTS
PILOT 2, RUN 2
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
N
SCALE IN FEET
0 500 1000 2000

FIGURE 41

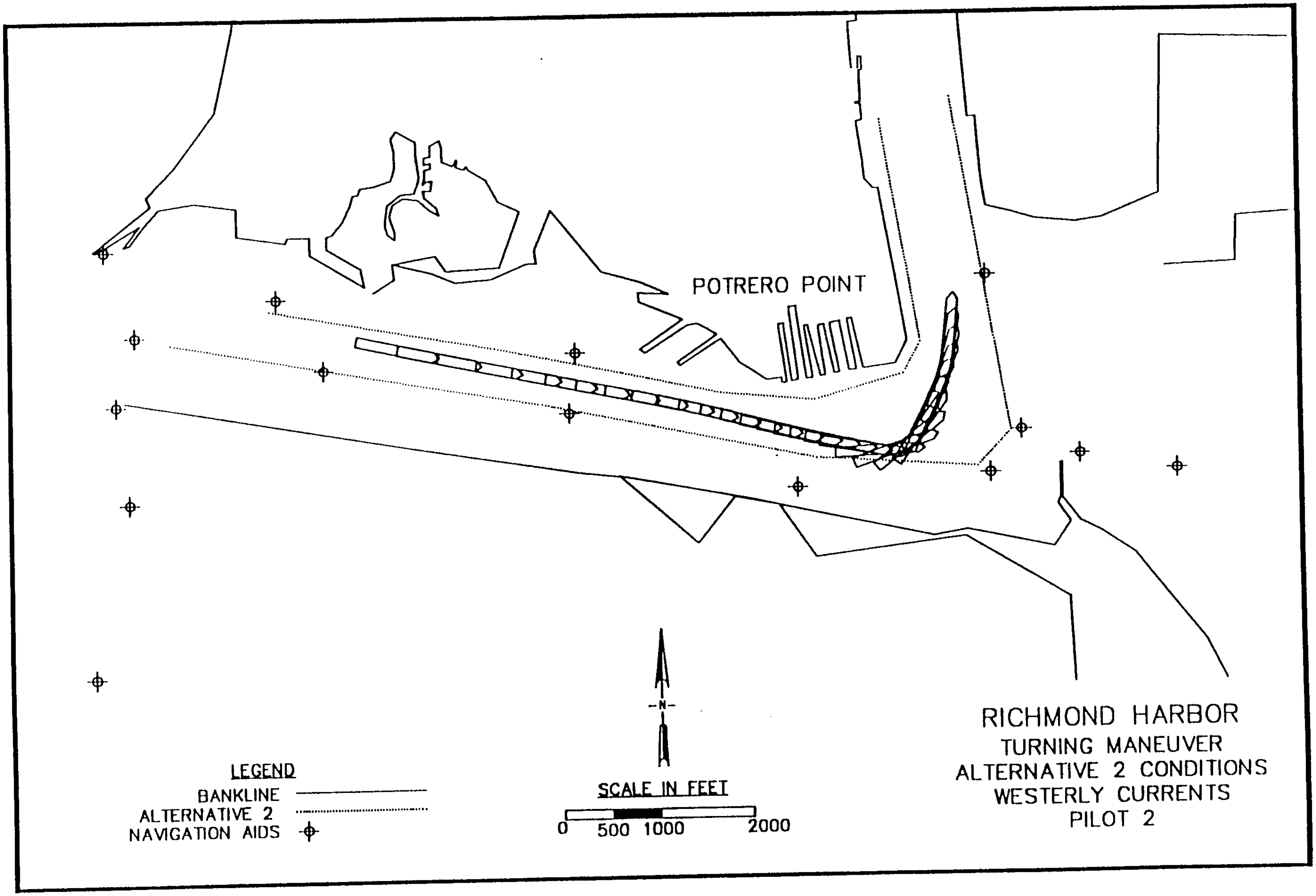

POTRERO POINT
N
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 2 CONDITIONS
WESTERLY CURRENTS
PILOT 2

FIGURE 4

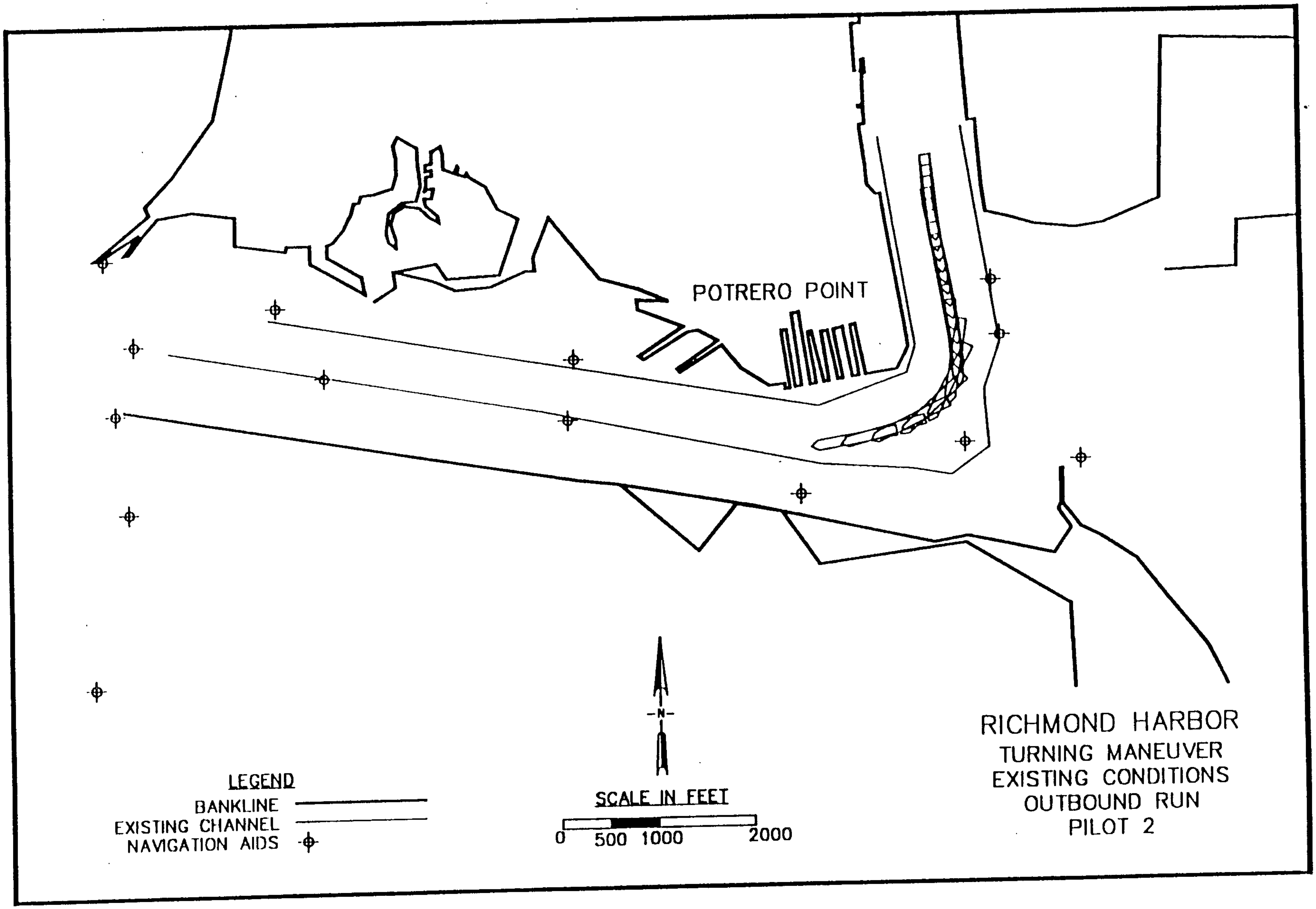
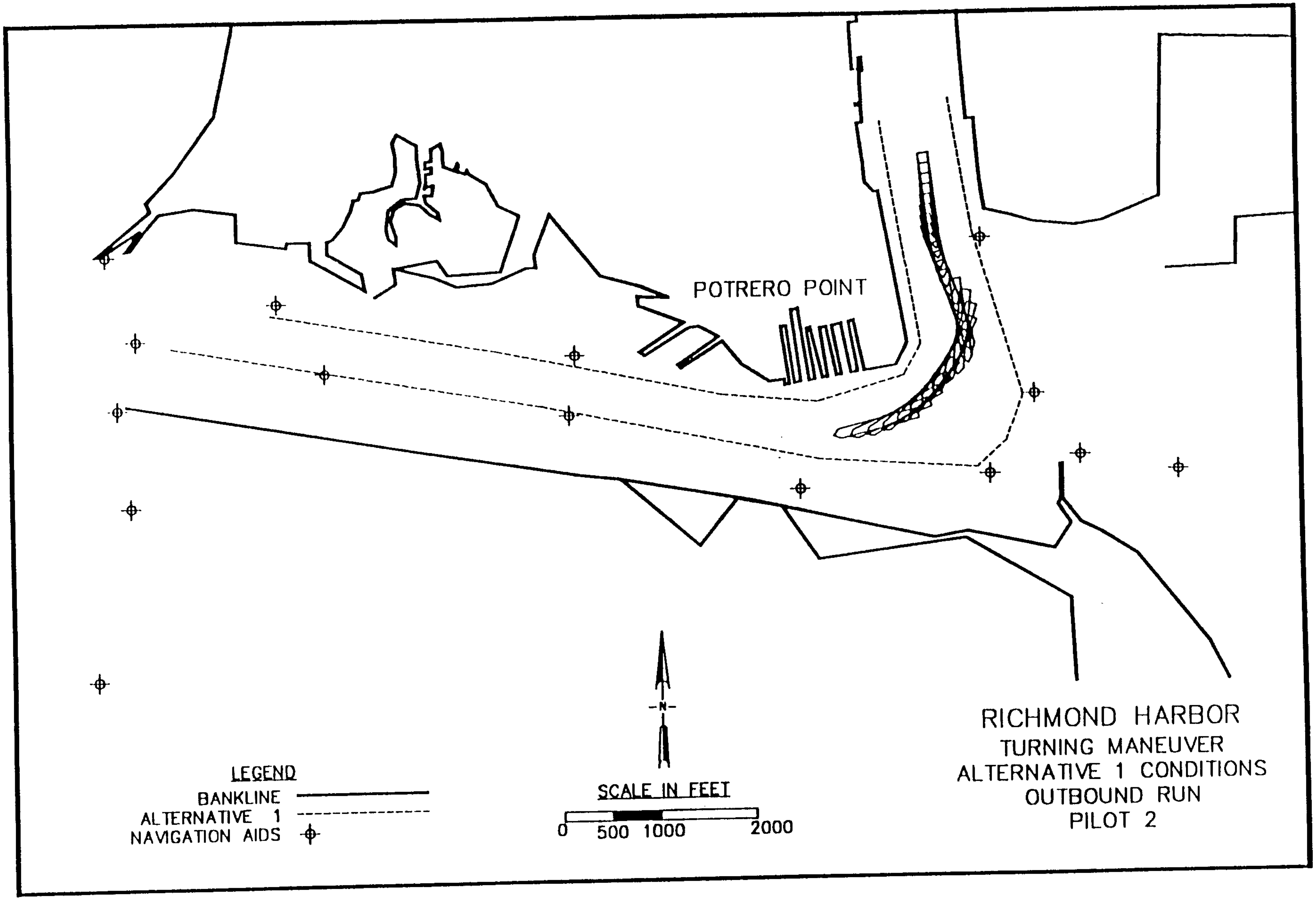
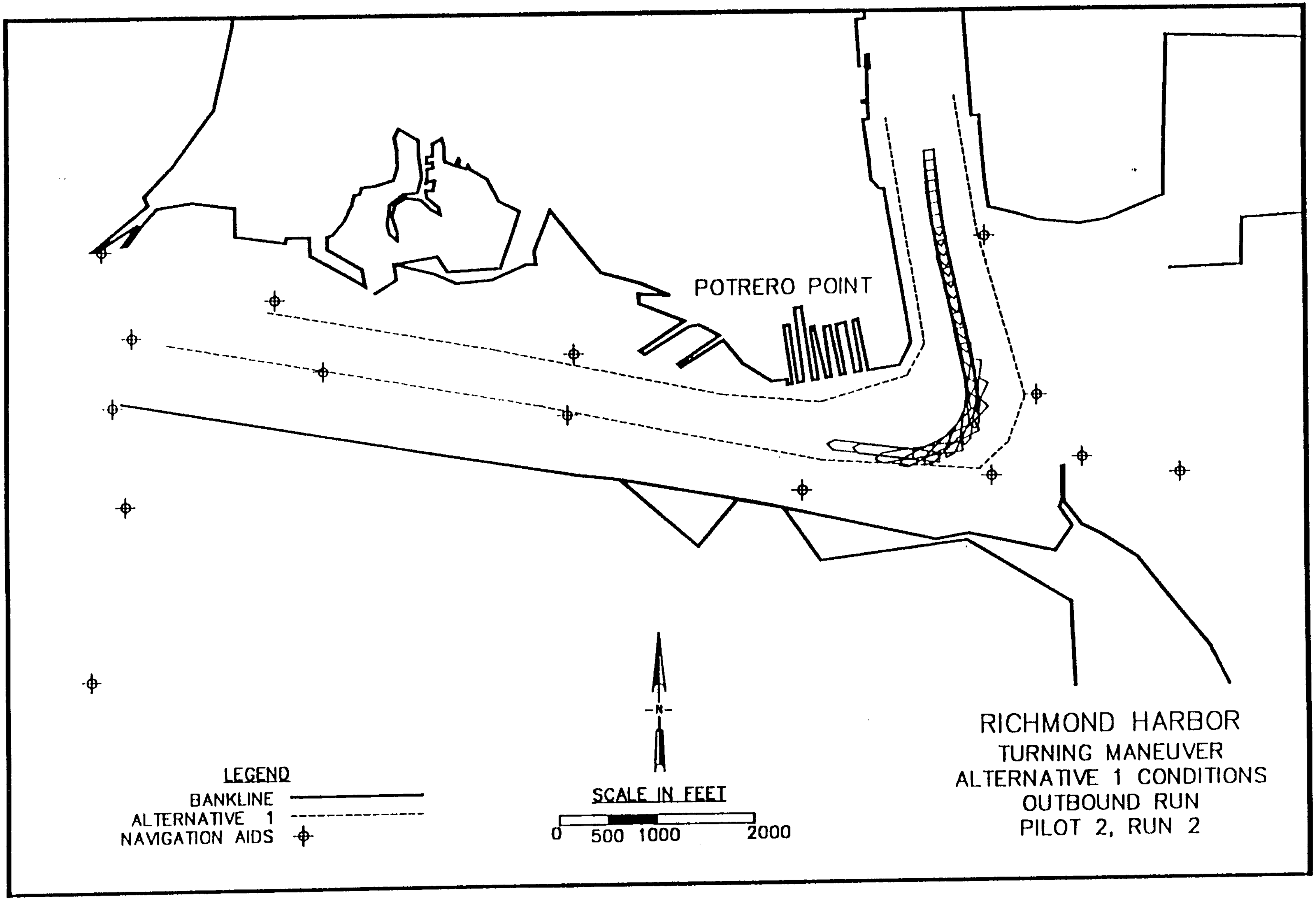

POTRERO POINT
RICHMOND HARBOR
TURNING MANEUVER
EXISTING CONDITIONS
OUTBOUND RUN
PILOT 2
LEGEND
BANKLINE
EXISTING CHANNEL
NAVIGATION AIDS
N
SCALE IN FEET
0 500 1000 2000

FIGURE 4.


POTRERO POINT
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 1 CONDITIONS
OUTBOUND RUN
PILOT 2
LEGEND
BANKLINE
ALTERNATIVE 1
NAVIGATION AIDS
SCALE IN FEET
0
500
1000
2000
N

FIGURE



RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 1 CONDITIONS
OUTBOUND RUN
PILOT 2, RUN 2

FIGURE 45

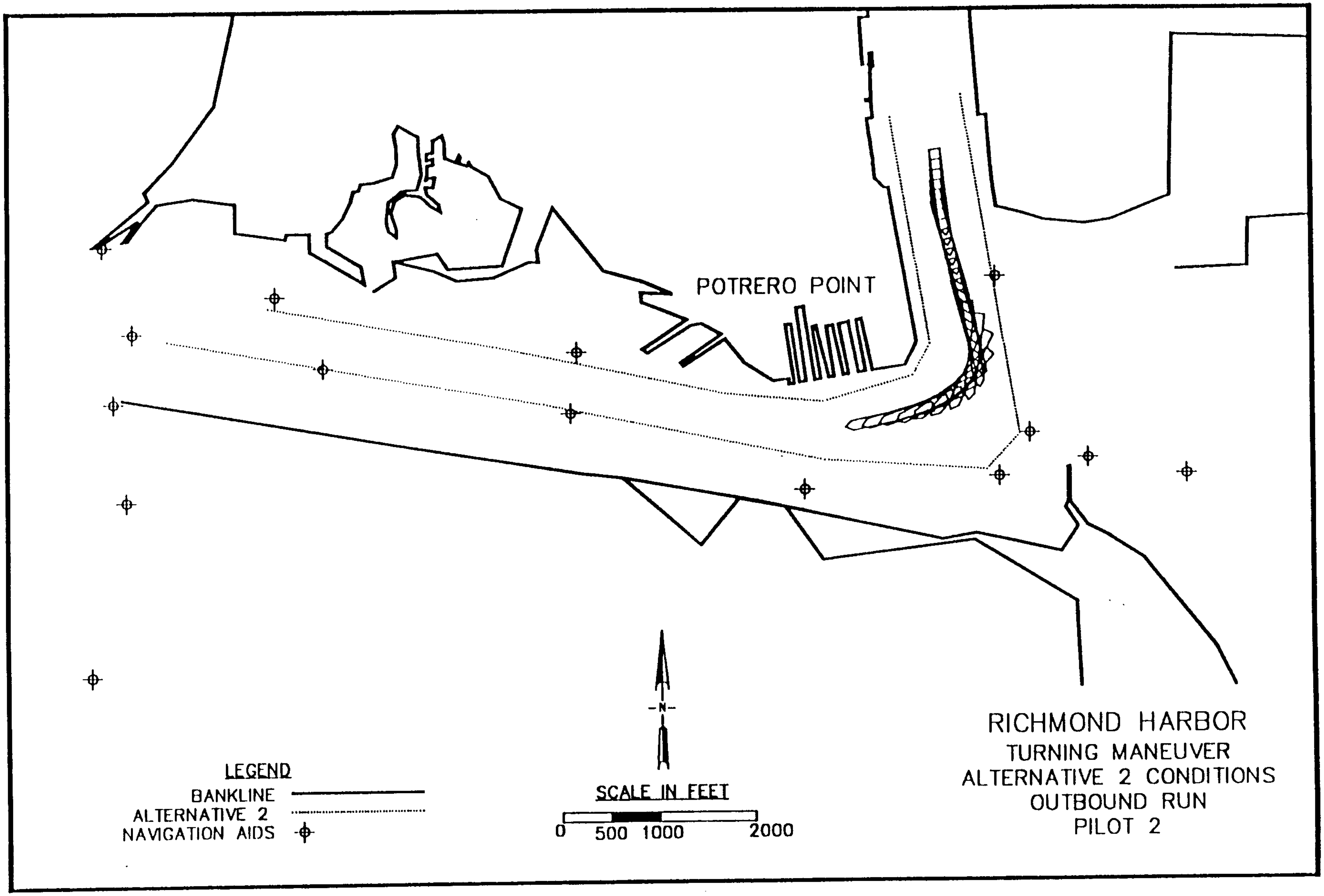

POTRERO POINT
-N-
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
SCALE IN FEET
0 500 1000 2000
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 2 CONDITIONS
OUTBOUND RUN
PILOT 2

FIGURE 4

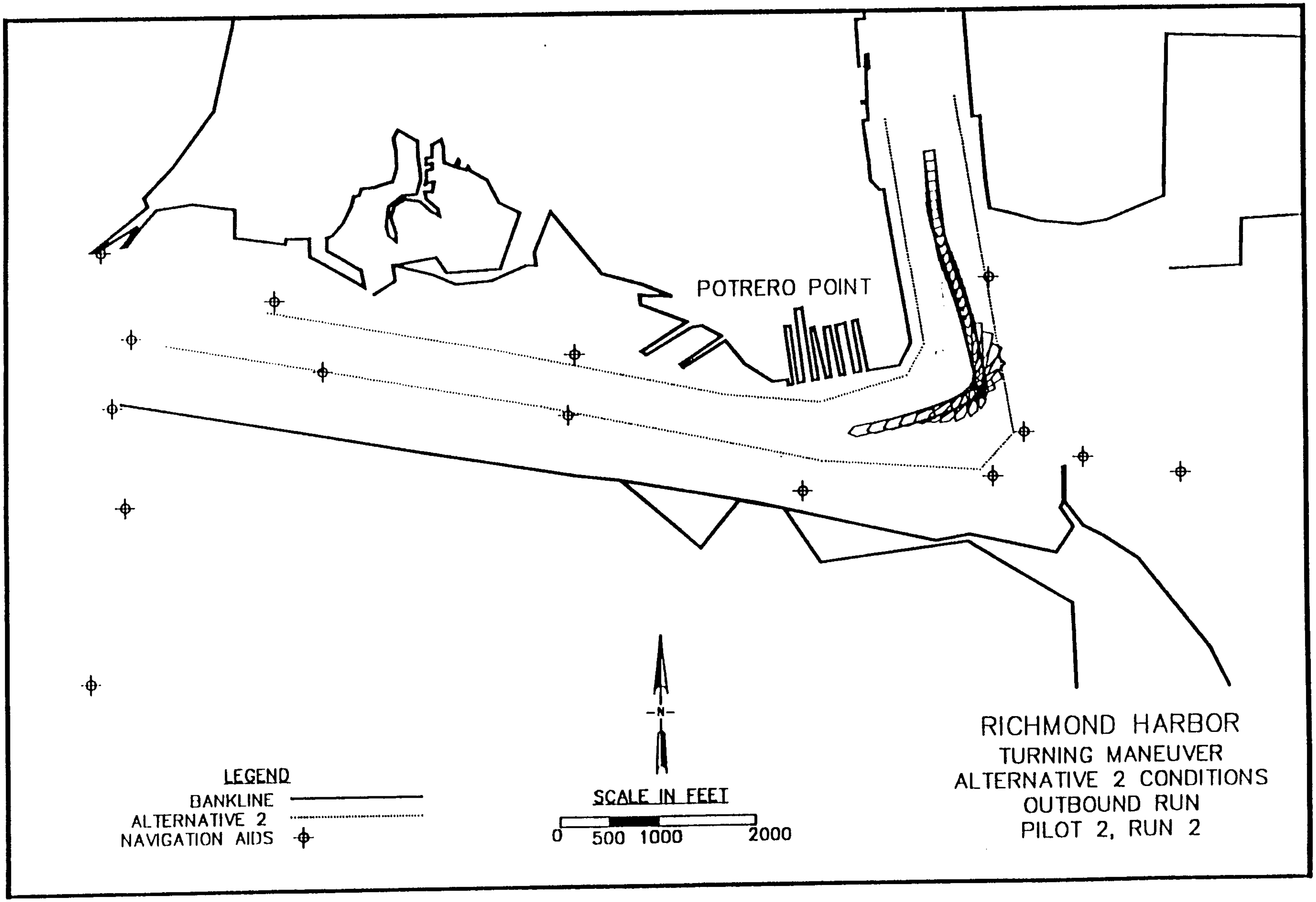
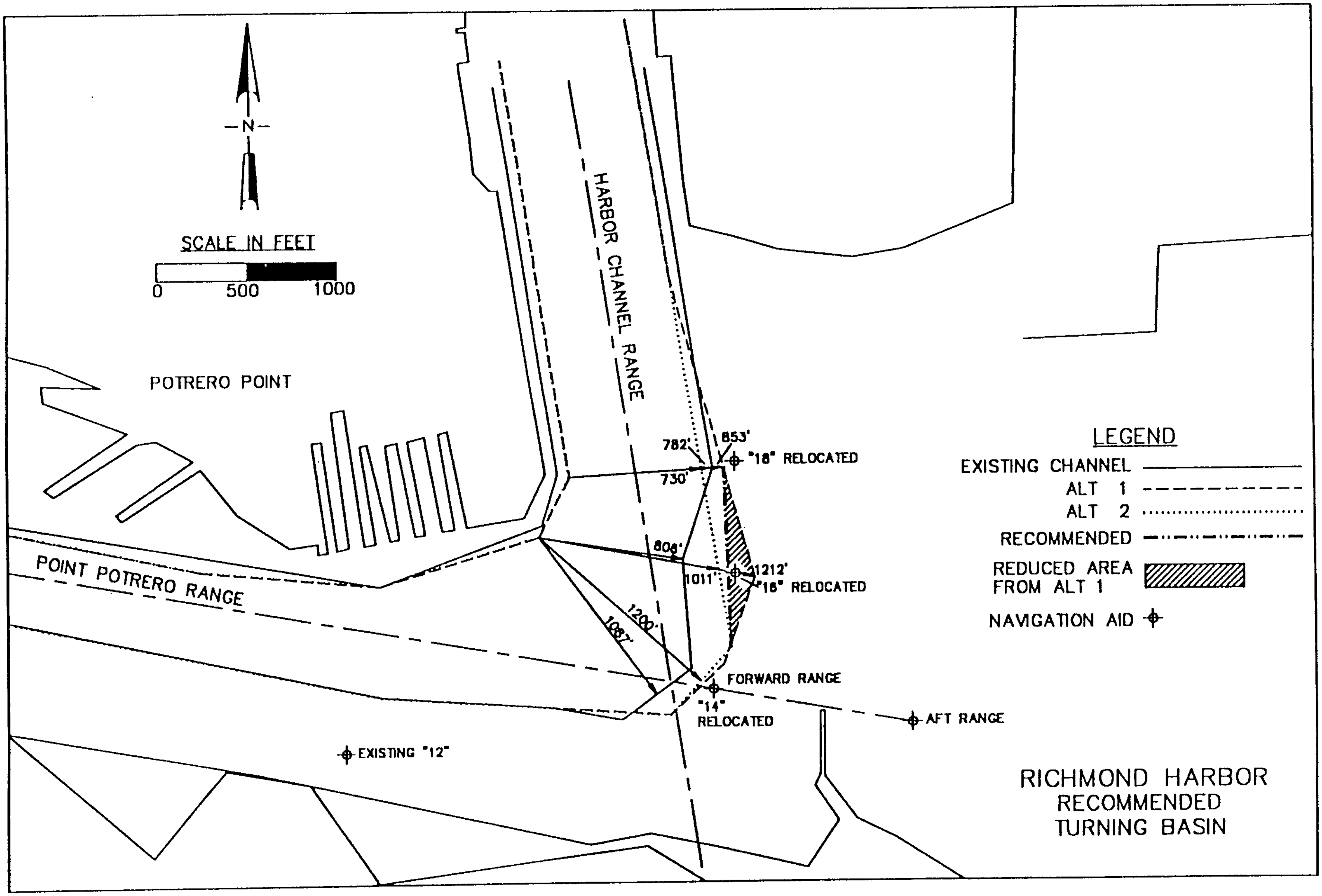

POTRERO POINT
RICHMOND HARBOR
TURNING MANEUVER
ALTERNATIVE 2 CONDITIONS
OUTBOUND RUN
PILOT 2, RUN 2
LEGEND
BANKLINE
ALTERNATIVE 2
NAVIGATION AIDS
-N-
SCALE IN FEET
0 500 1000 2000

FIGURE 4


SCALE IN FEET
0
500
1000
N
POTRERO POINT
HARBOR CHANNEL RANGE
POINT POTRERO RANGE
782'
853'
"18" RELOCATED
730'
806'
1011'
1212'
"16" RELOCATED
1200'
1087'
FORWARD RANGE
"14"
RELOCATED
AFT RANGE
EXISTING "12"
LEGEND
EXISTING CHANNEL
ALT 1
ALT 2
RECOMMENDED
REDUCED AREA FROM ALT 1
NAVIGATION AID
RICHMOND HARBOR
RECOMMENDED
TURNING BASIN

FIGURE

APPENDIX A

CEWES-HE-P 29 June 94

MEMORANDUM FOR Carl Huval

SUBJECT: Hydrodynamics for Richmond Harbor (San Francisco Bay) Existing Channel Conditions

The hydrodynamics for the Richmond Harbor existing channel conditions have been completed for support of the ship simulator. The currents were developed with the 2D model (RMA-2).

Geometry

The channel for the existing condition was 36 ft deep (authorized 35 ft plus 1 ft allowable overdepth). The horizontal alignment of the channel was defined as shown in Figure 1. The details of the turn are presented in Figure 2. For the numerical model mesh the x-coordinate had a constant 1,000,000 ft subtracted from the coordinates shown in Figure 1 inset table.

The overall computational mesh is shown in Figure 3 and the details of the Richmond Harbor area in Figure 4. The bathymetric contours in the channel turning area are presented in Figure 5, with mean lower low water (MLLW) at an elevation of 400 ft. A contour value of 365 is therefore 35 ft deep.

Boundary Conditions

The tidal boundary condition used in the simulation is shown in Figure 6. Note that there is a 12 hour filter applied at the beginning of the simulation strictly for smooth numerical transition. The tides are for the period of 10-17 June 1992, a portion of the period when the overall model was verified. These tides are an average spring tide condition. The freshwater inflows to the system were for a low discharge condition and have no bearing on the currents in the Richmond Harbor area. No wind forcing was applied.

Coefficients

The model coefficients were defined using the options in version 429 of RMA-2 which allow for the specification of the Peclet number directly and the computation of the friction factor as a function of water depth. These coefficients therefore vary dynamically over the simulation. The Peclet number was set at 40 for the 2D portions of the mesh and at 20 for the 1D delta. This generally results in much lower eddy viscosities than the conventional approach.

Results

The tidal response in Richmond Harbor for the existing channel condition is shown in Figure 7. The resulting velocity variations at the selected nodes shown in Figure 8, are presented in Figures 9-16. The time series plots present the magnitude of the currents with the sign of the easterly component of the current velocity. The currents in the area are complex and the pilots should view the tidal animation on their visit. The peak easterly and westerly currents occurred at hours 79.5 and 95 during the final tidal cycle. Notice in Figure 7 that these peak currents occur at approximately low water for the easterly currents and high water for the westerly currents. The current vectors for the general area are presented in Figures 17 and 18 for those hours. Notice that the peak easterly currents occur at a time when the general estuarine circulation is in a state of change from ebb to flood. The peak westerly currents occur a full flood condition in the overall system. The local current conditions in Richmond Harbor for those hours are presented in Figures 19 and 20.

Data Availability

These existing channel currents will be available on 'h1', the local SGI microcomputer in the following files:

letter/sanfran/richexme.extract - extract file for maximum easterly currents

letter/sanfran/richexmw.extract - extract file for maximum westerly currents

At the time of this draft memorandum the CRAY was down for repairs. As soon as it becomes available the files will be transferred.

J.V. Letter

Joe Letter
Estuarine Processes Branch

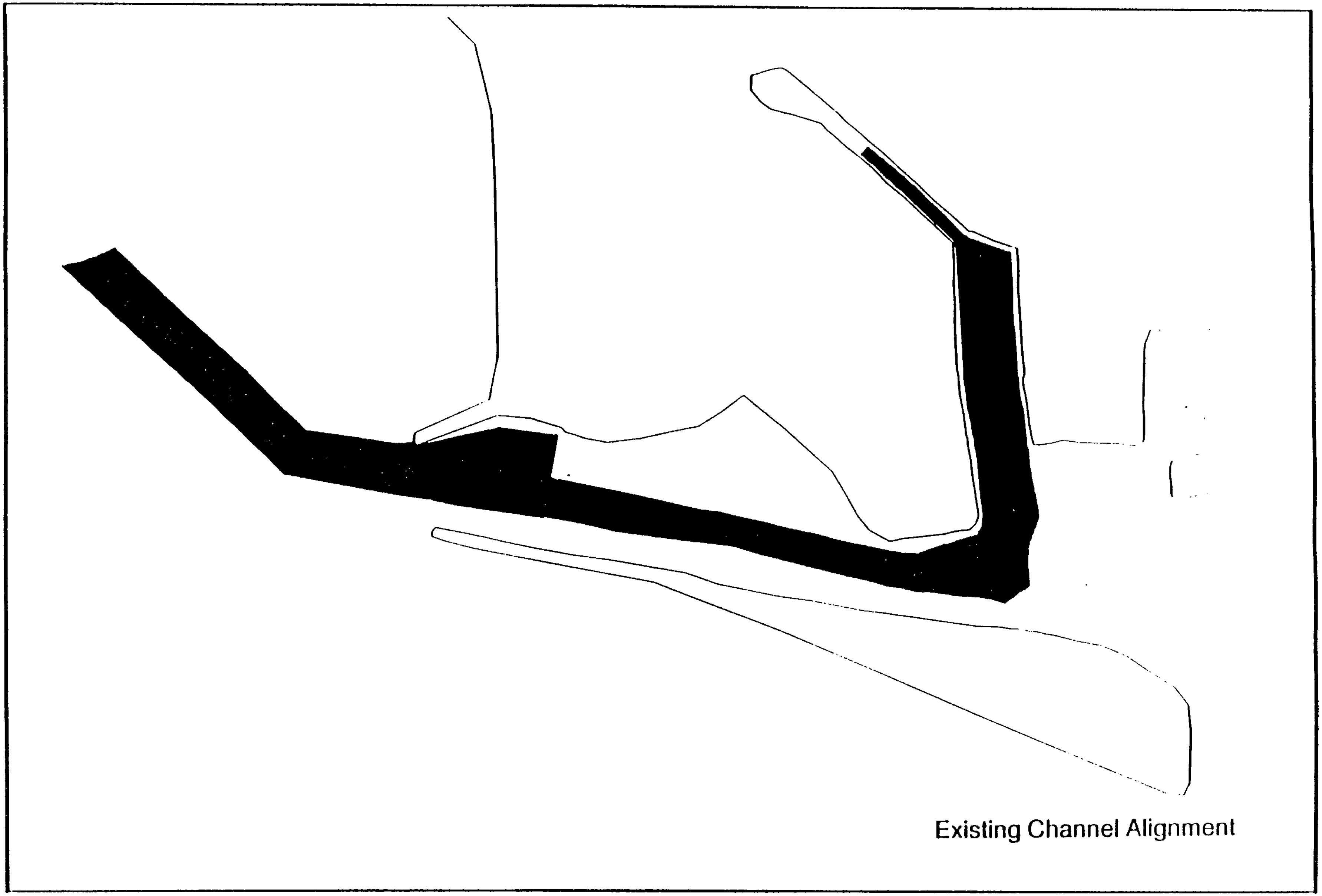
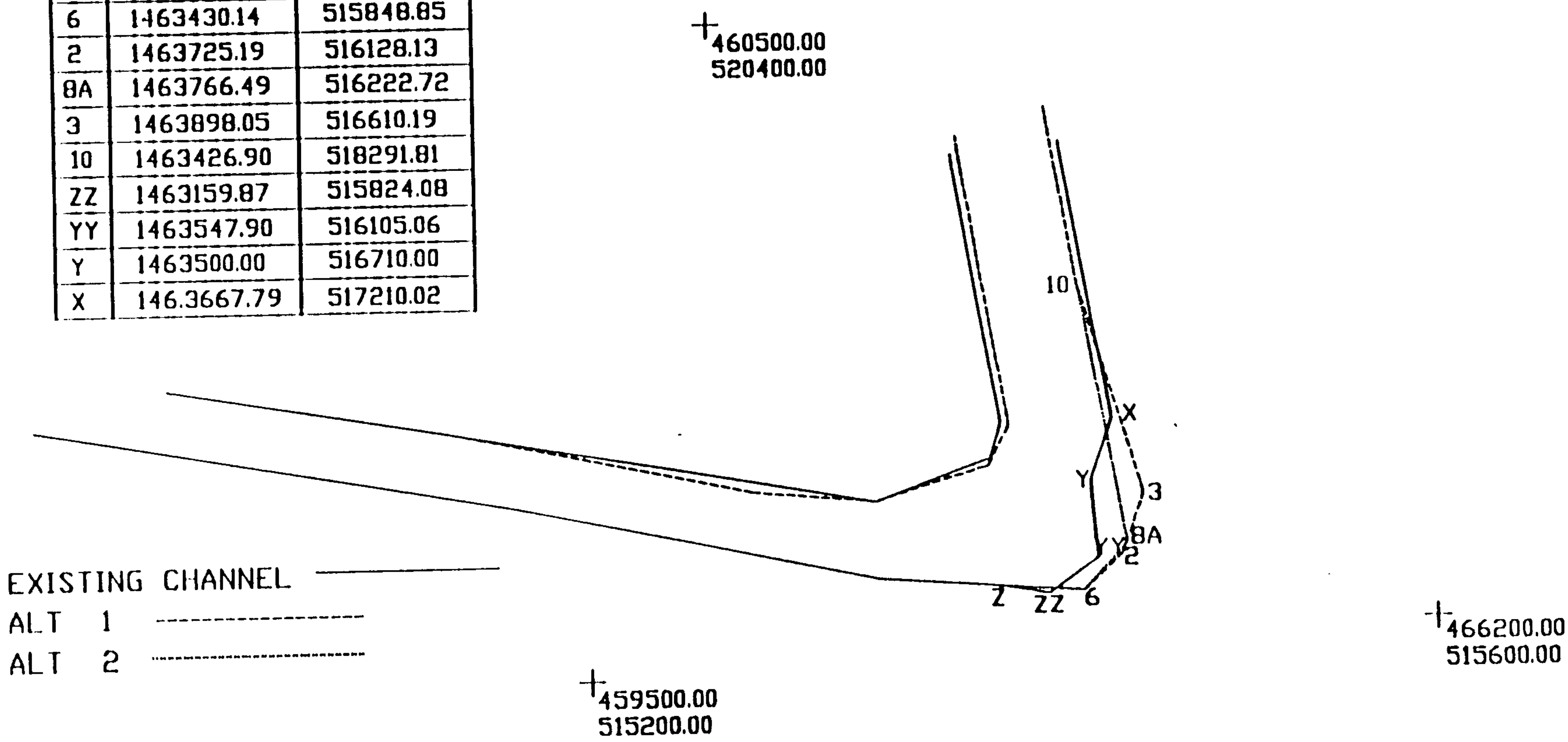


Figure 1

∠	X	Y
Z	1462773.34	515893.70
6	1463430.14	515848.85
2	1463725.19	516128.13
8A	1463766.49	516222.72
3	1463898.05	516610.19
10	1463426.90	518291.81
ZZ	1463159.87	515824.08
YY	1463547.90	516105.06
Y	1463500.00	516710.00
X	146.3667.79	517210.02



Channel Alignment Alternatives
Critical Channel Turn

Figure 2

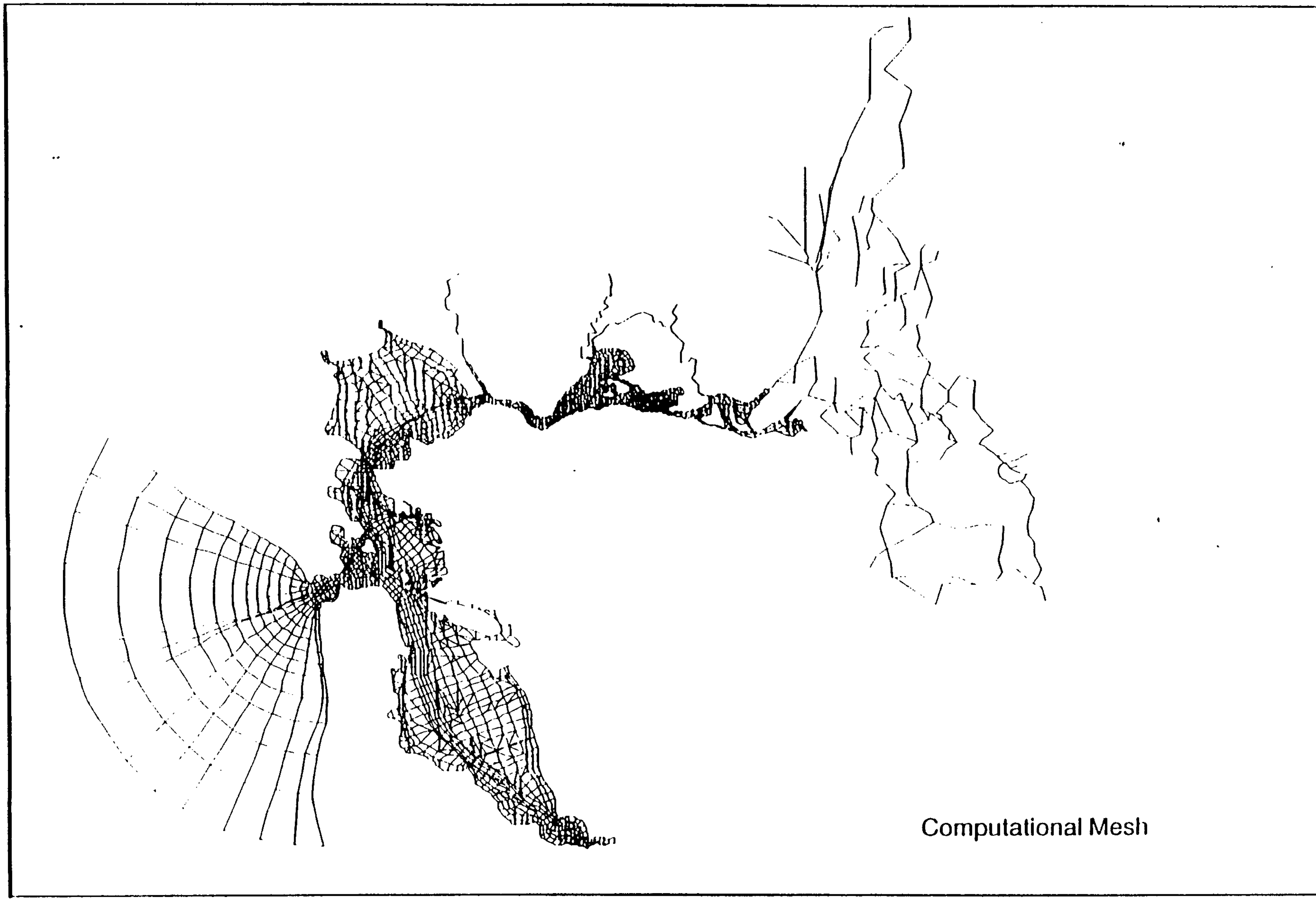


Figure 3

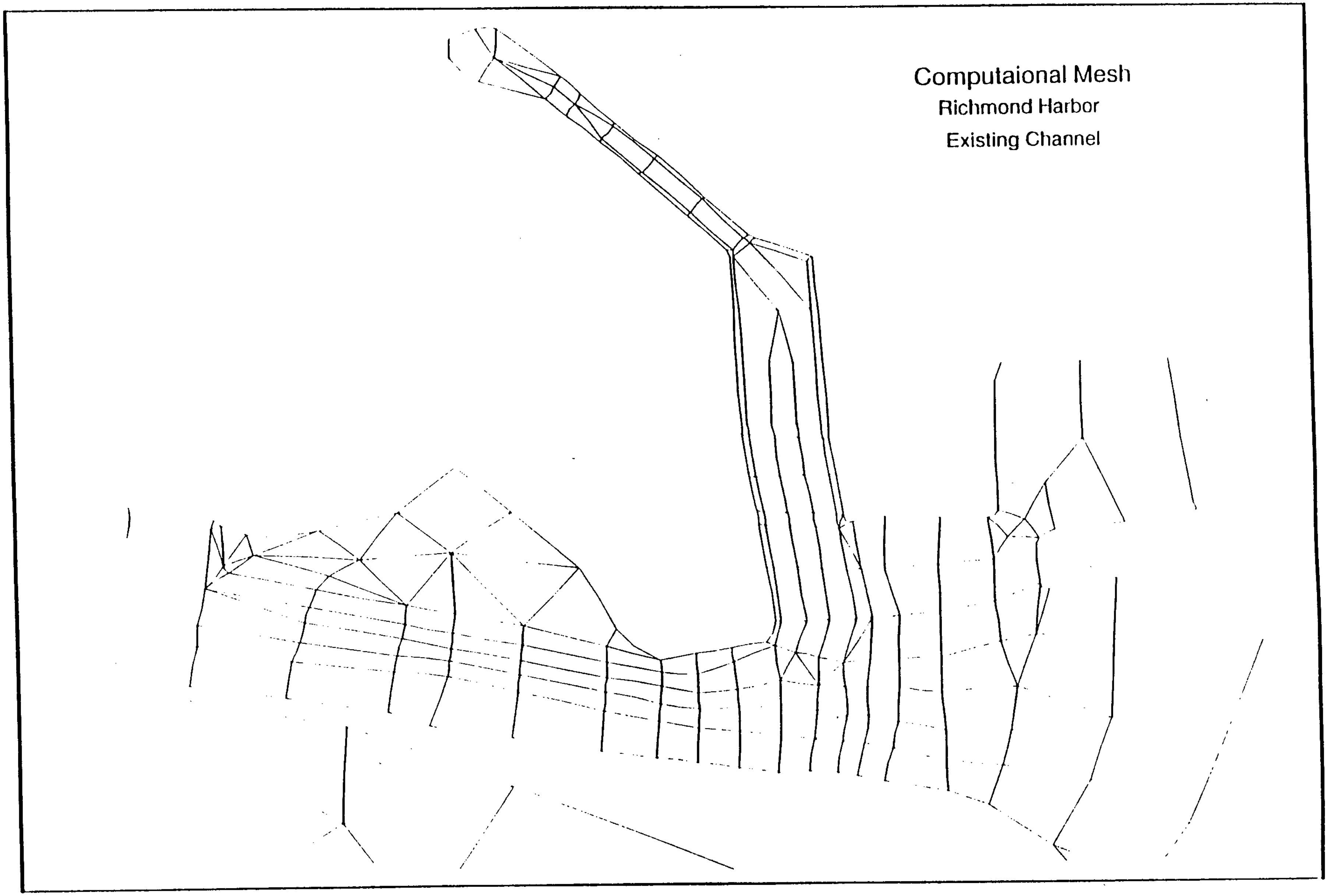
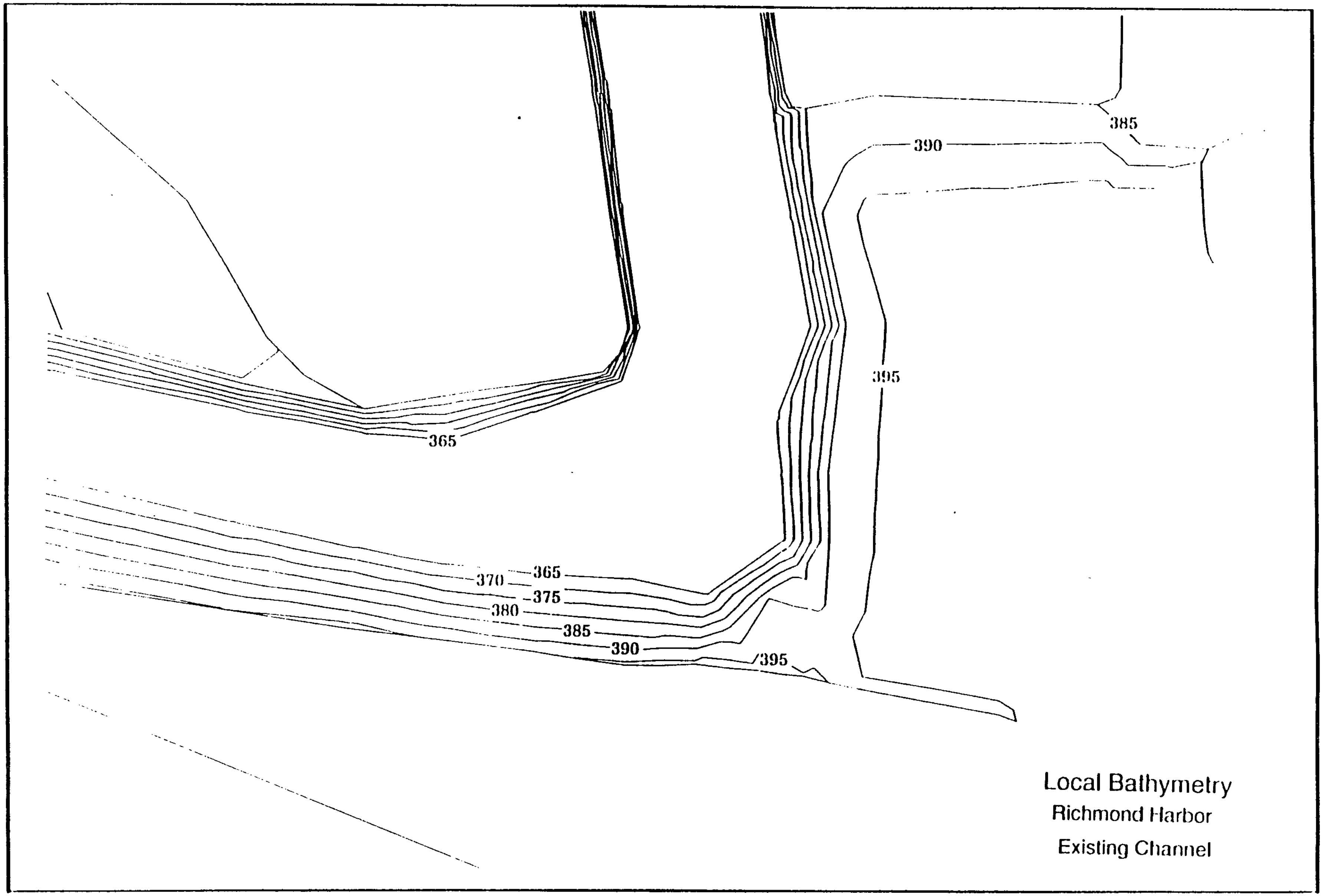
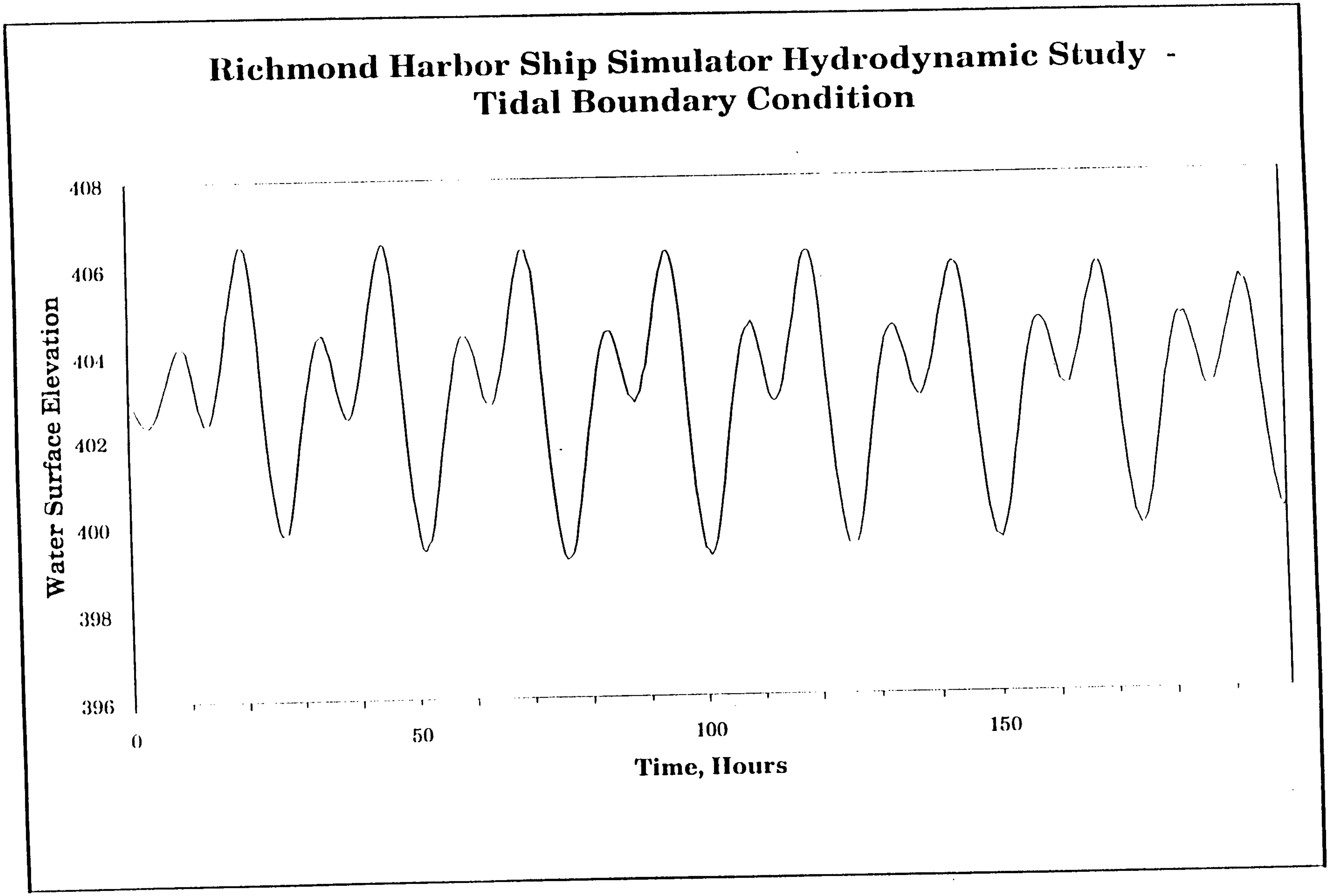


Figure 4



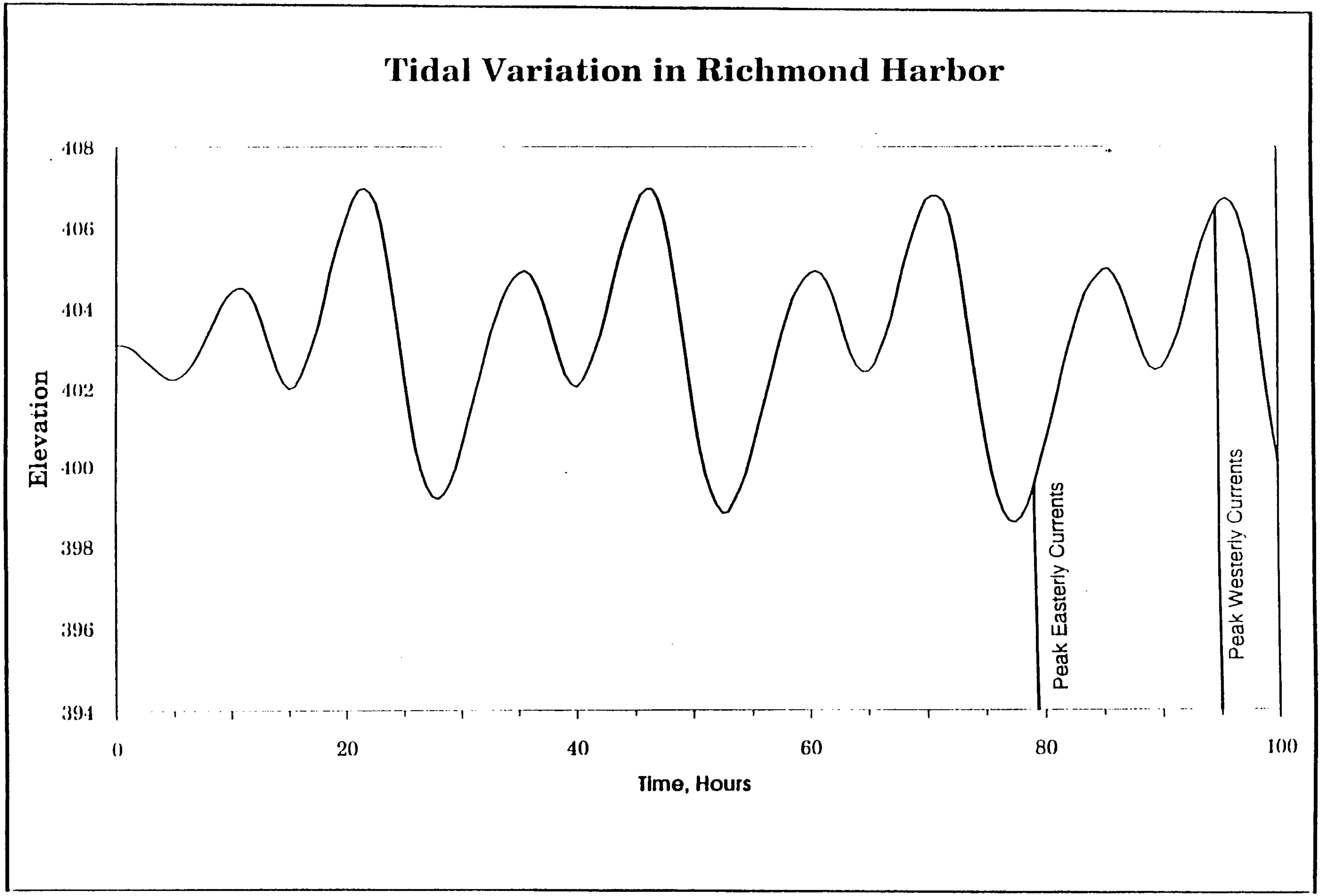
Local Bathymetry
Richmond Harbor
Existing Channel
365
370
375
380
385
390
395

Figure 5



Richmond Harbor Ship Simulator Hydrodynamic Study - Tidal Boundary Condition
Water Surface Elevation
408
406
404
402
400
398
396
0
50
100
150
Time, Hours

Figure 6



Tidal Variation in Richmond Harbor
408
406
404
402
400
398
396
394
Elevation
0
20
40
60
80
100
Time, Hours
Peak Easterly Currents
Peak Westerly Currents

Figure 7

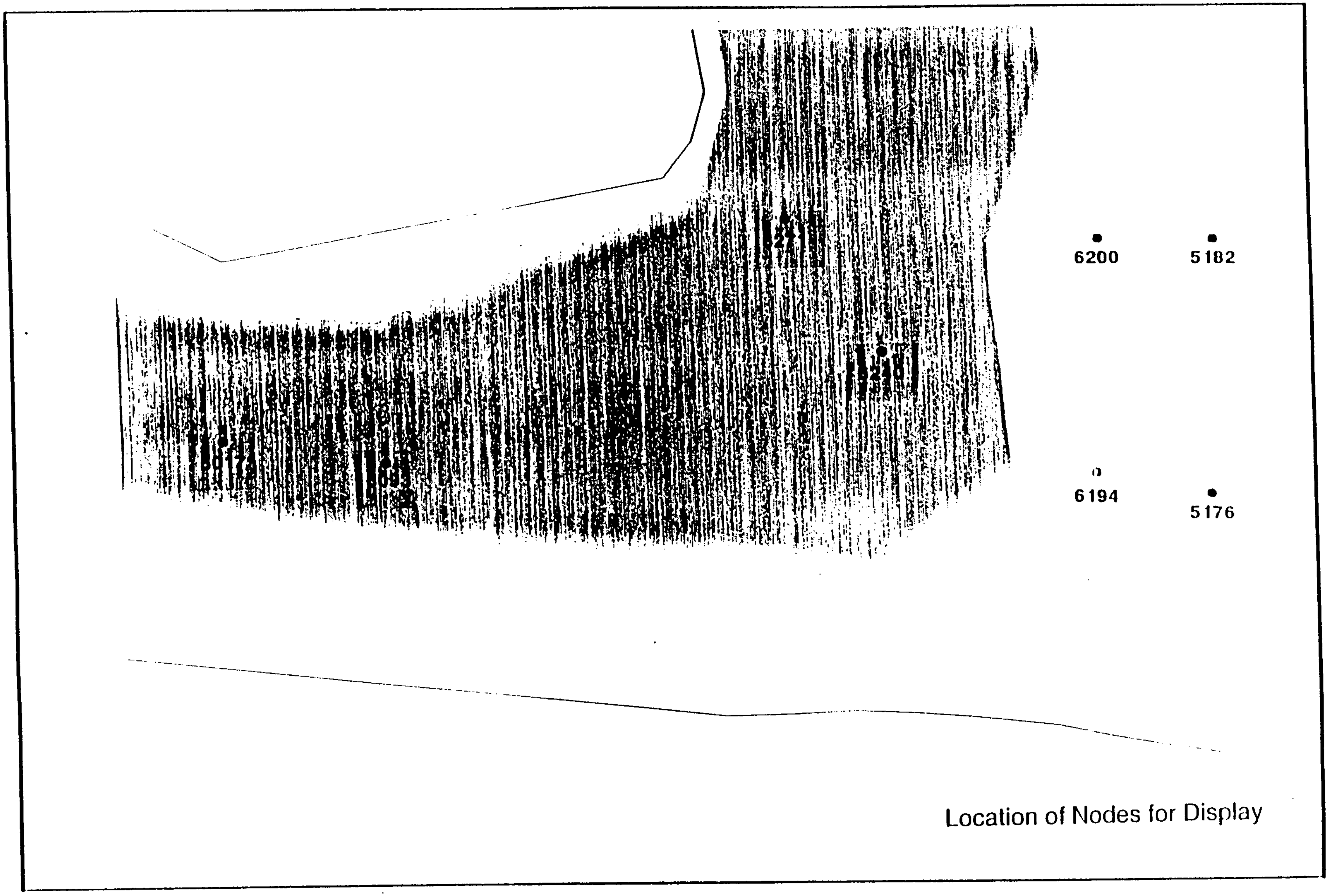
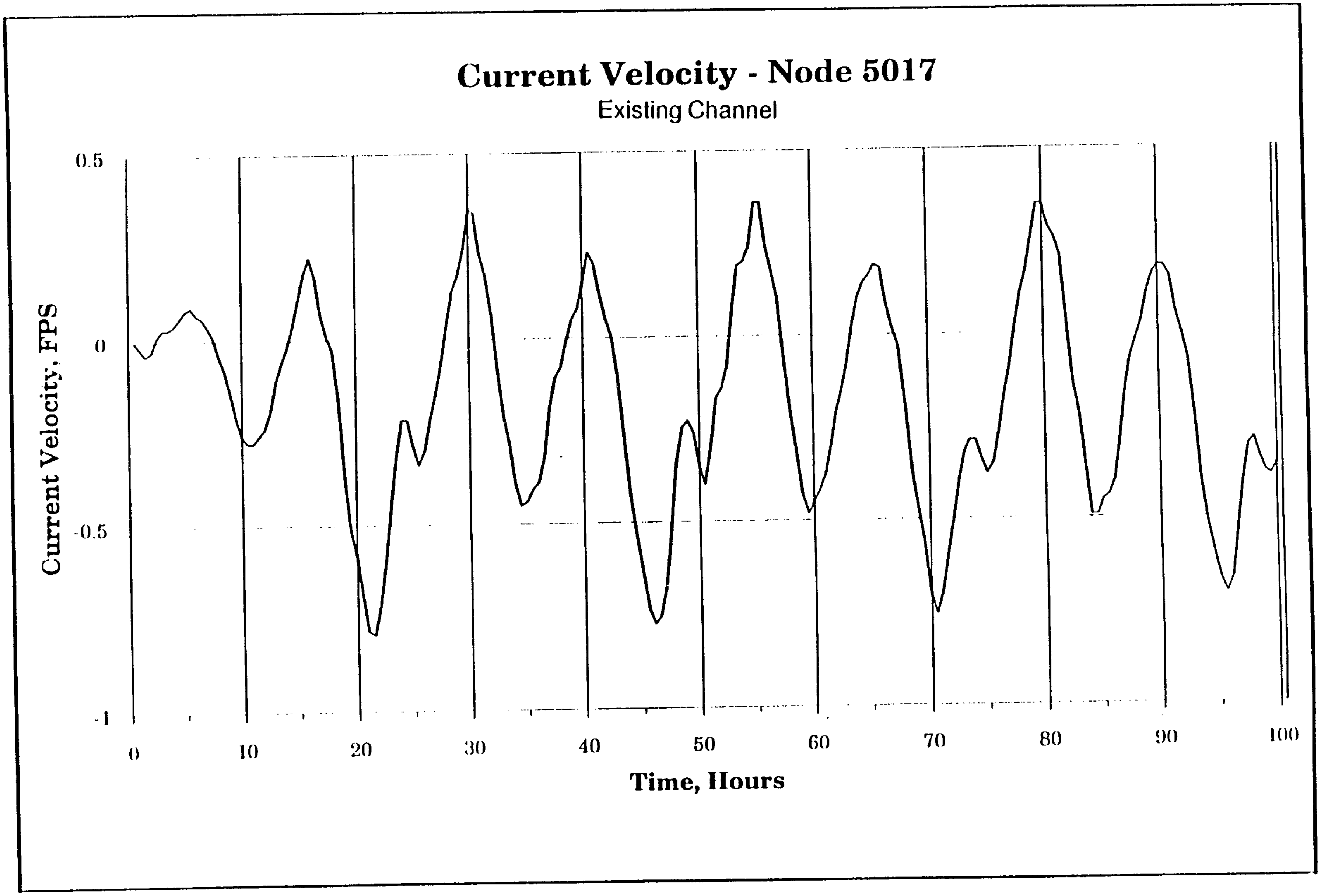


Figure 8



Current Velocity - Node 5017
Existing Channel
Current Velocity, FPS
0.5
0
-0.5
-1
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 9

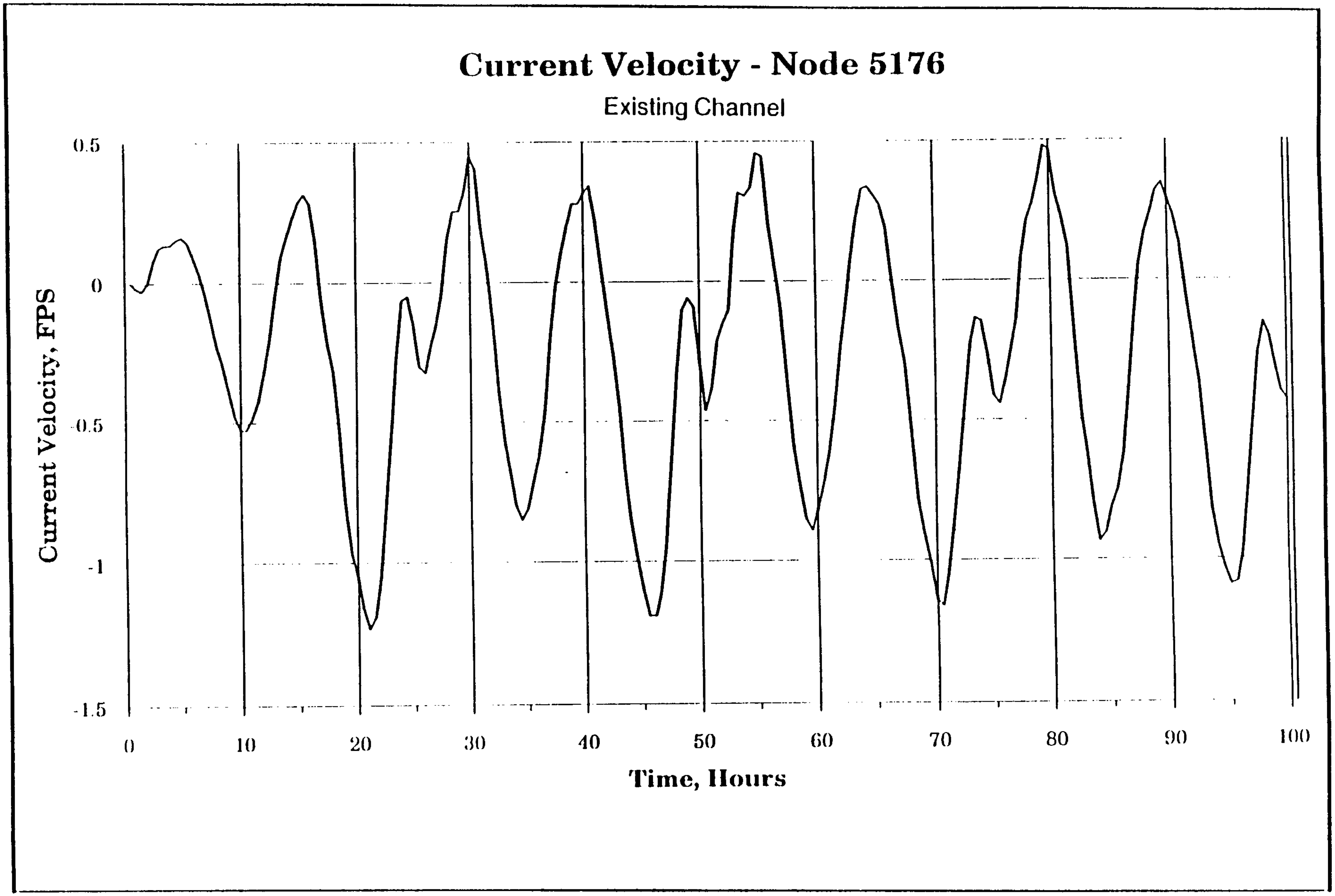

Current Velocity - Node 5176
Existing Channel
0.5
0
-0.5
-1
-1.5
Current Velocity, FPS
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 10

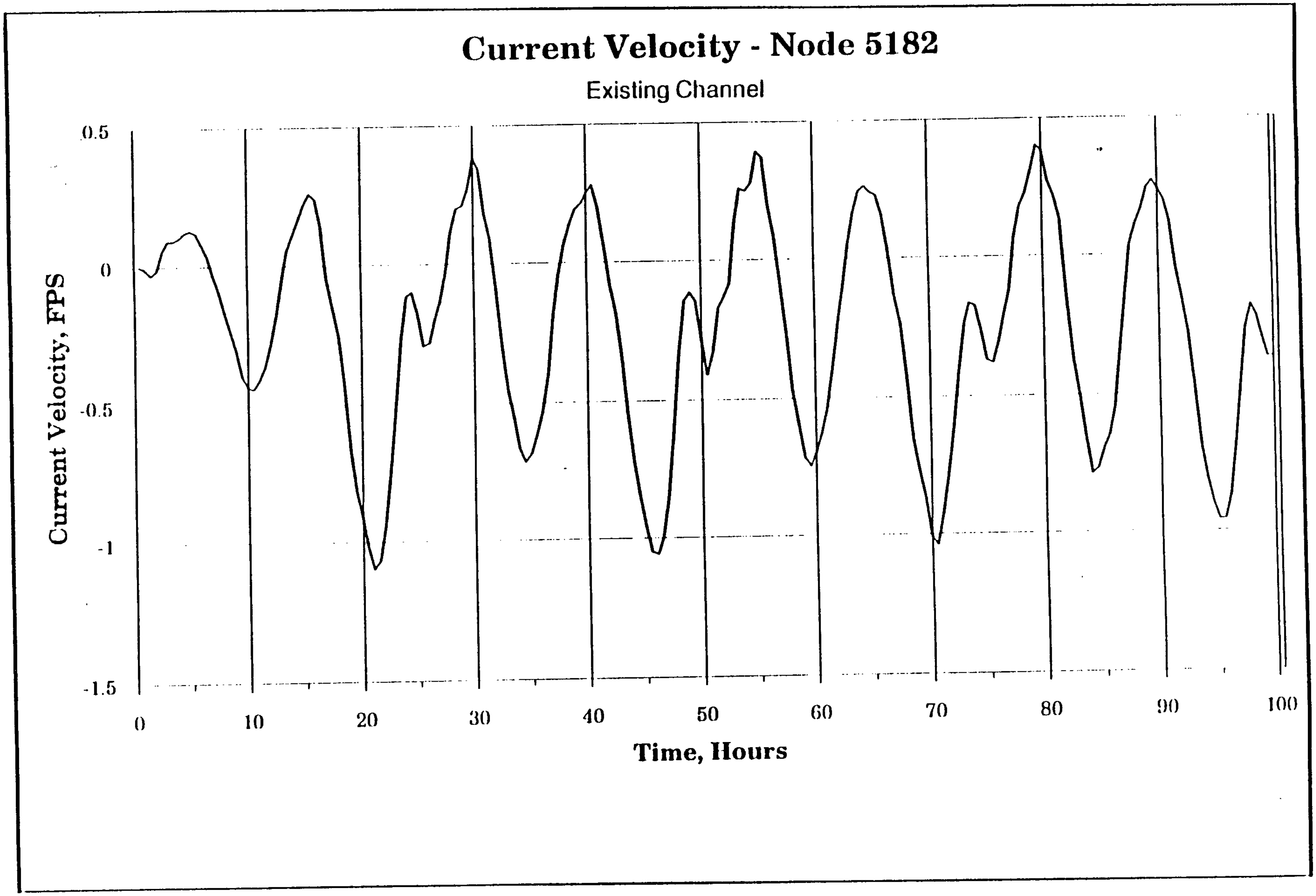

Current Velocity - Node 5182
Existing Channel
Current Velocity, FPS
0.5
0
-0.5
-1
-1.5
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 11

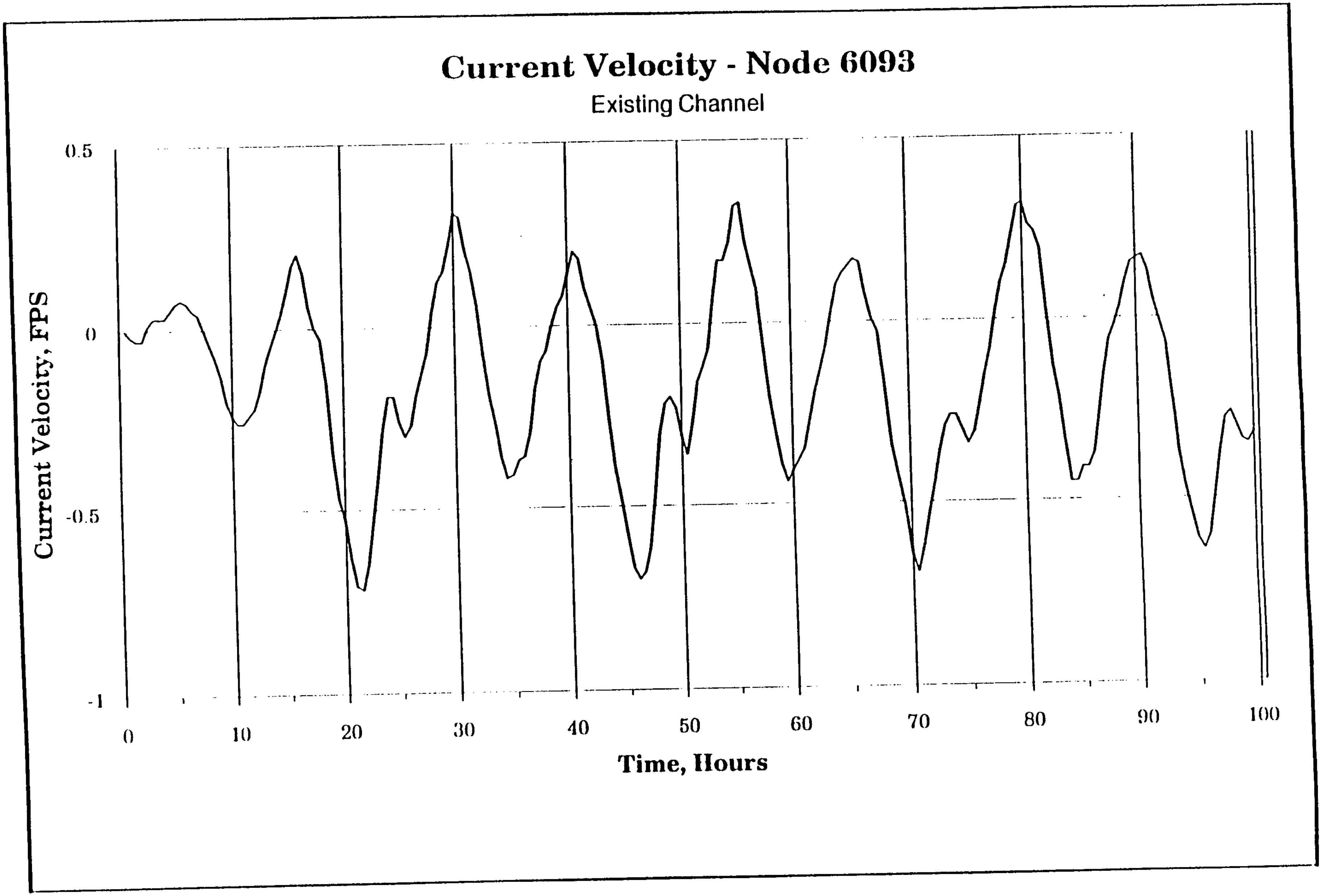
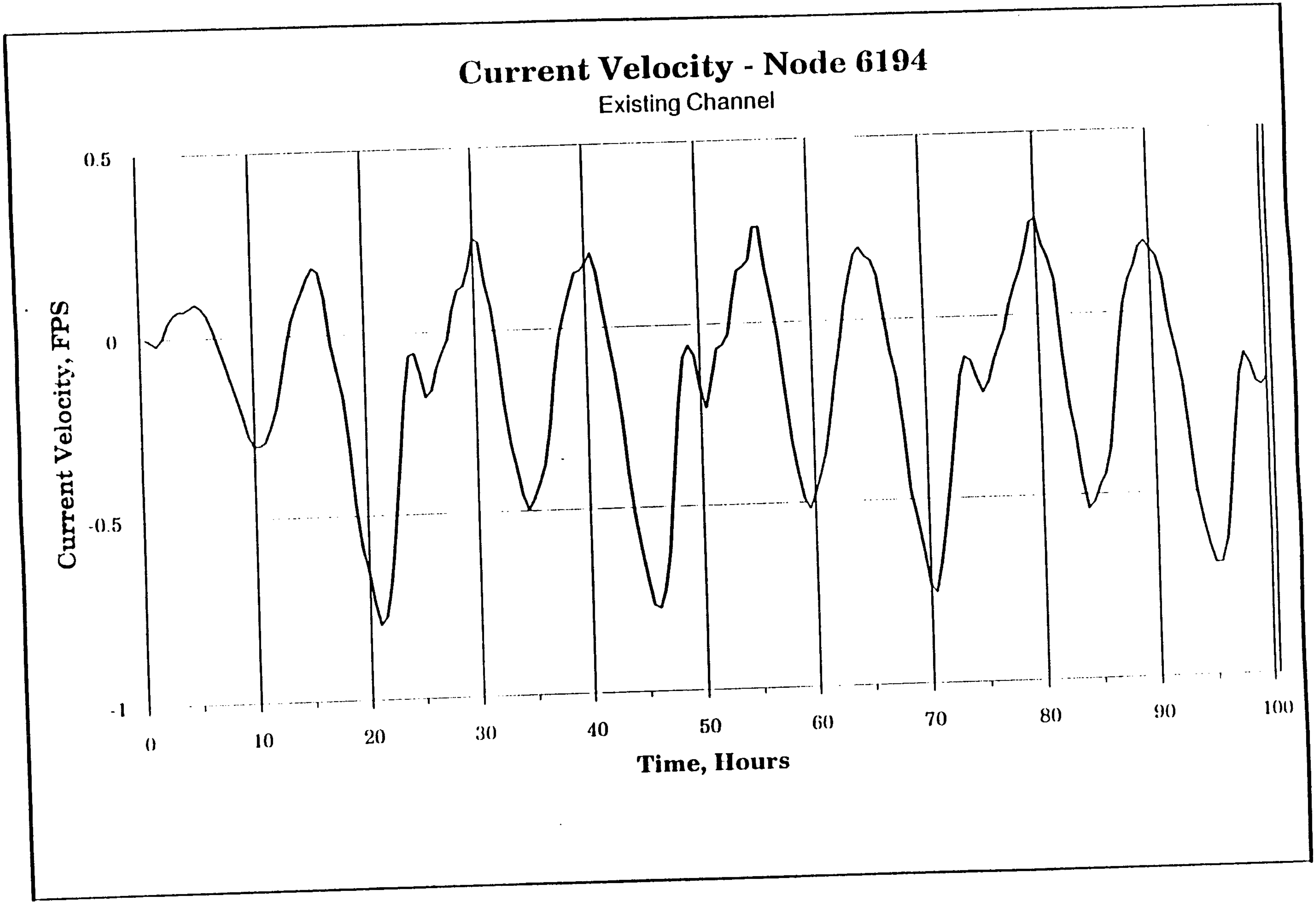

Current Velocity - Node 6093
Existing Channel
Current Velocity, FPS
0.5
0
-0.5
-1
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 12



Current Velocity - Node 6194
Existing Channel
Current Velocity, FPS
0.5
0
-0.5
-1
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 13

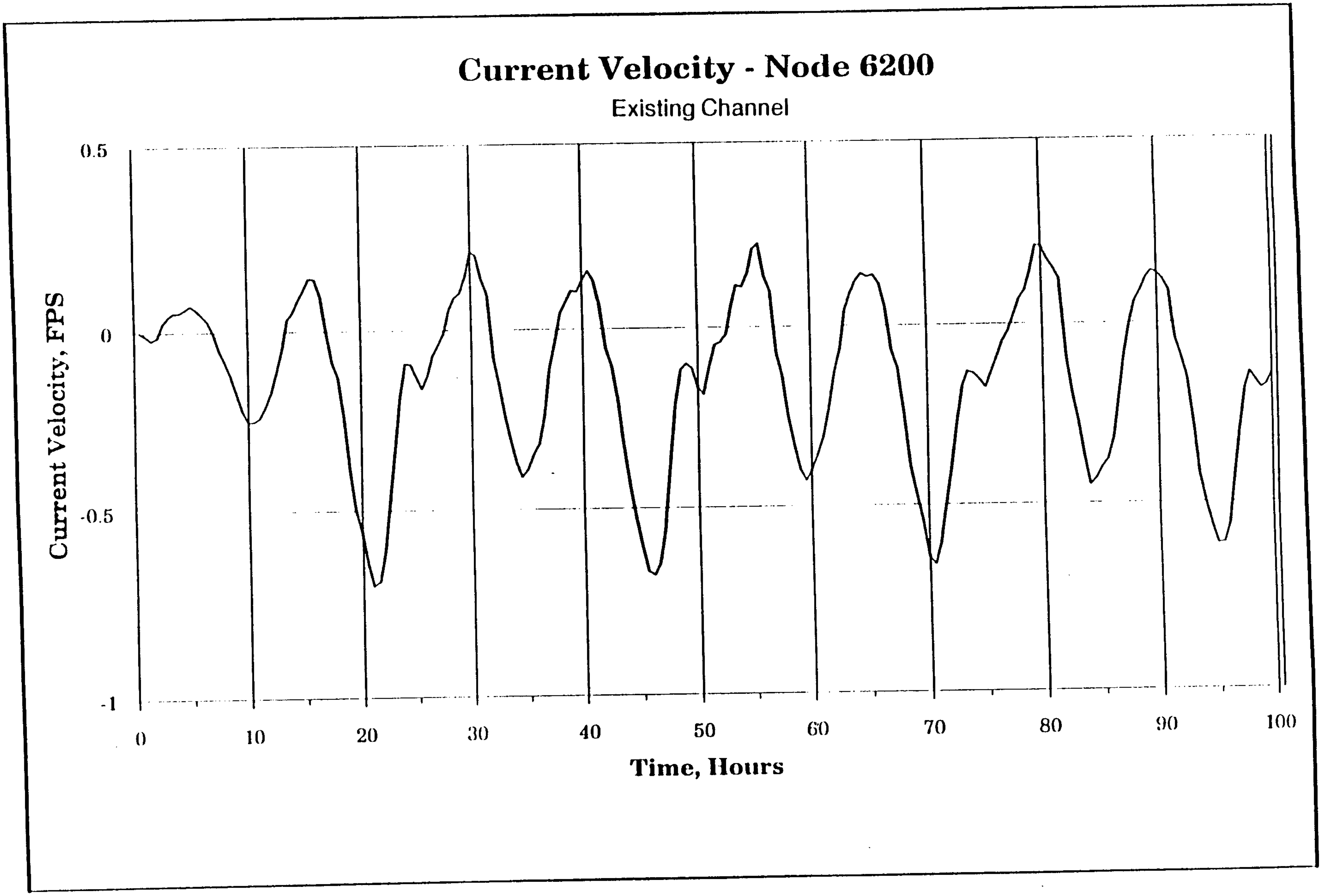

Current Velocity - Node 6200
Existing Channel
Current Velocity, FPS
0.5
0
-0.5
-1
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 1-1

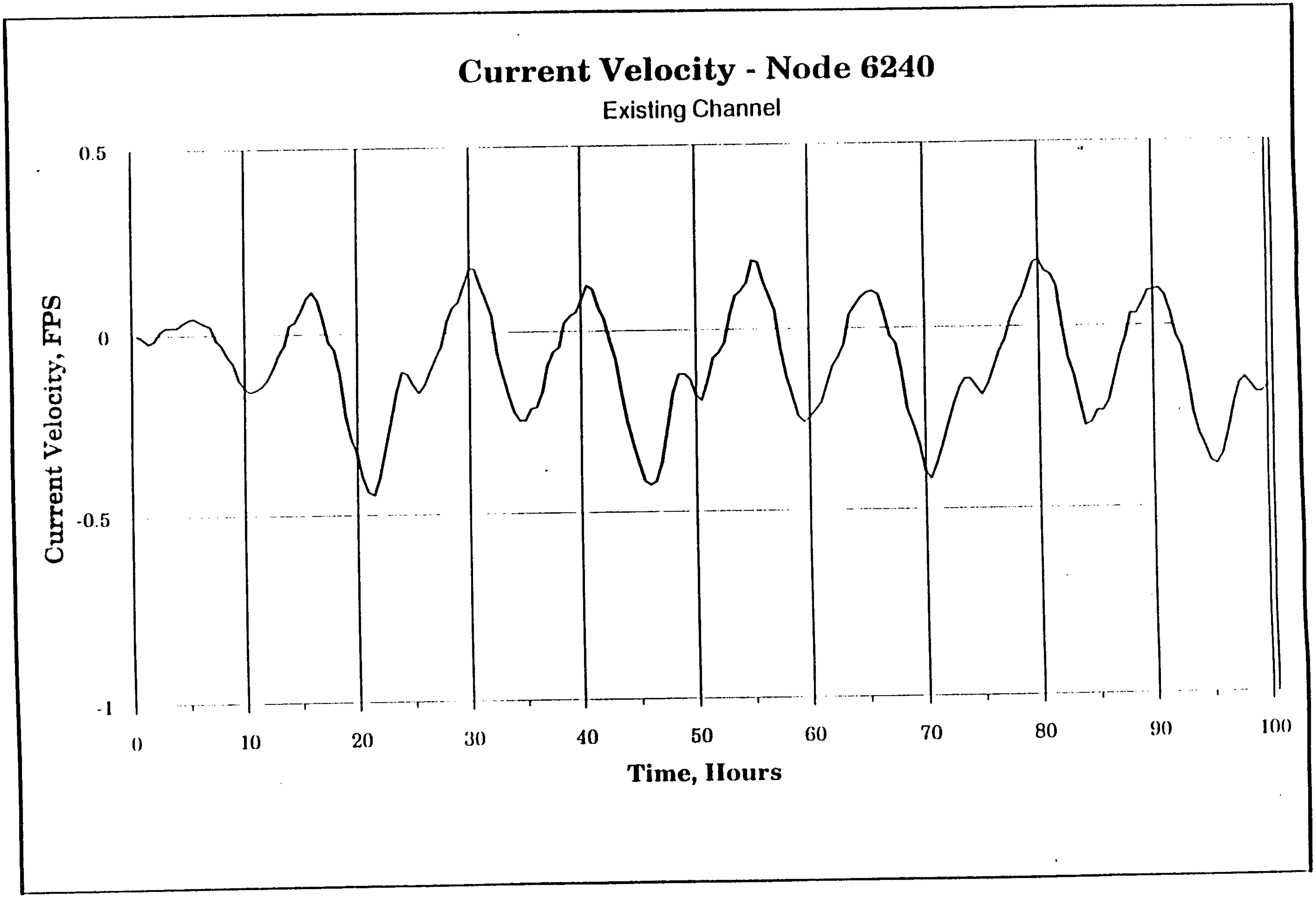

Current Velocity - Node 6240
Existing Channel
Current Velocity, FPS
0.5
0
-0.5
-1
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 15

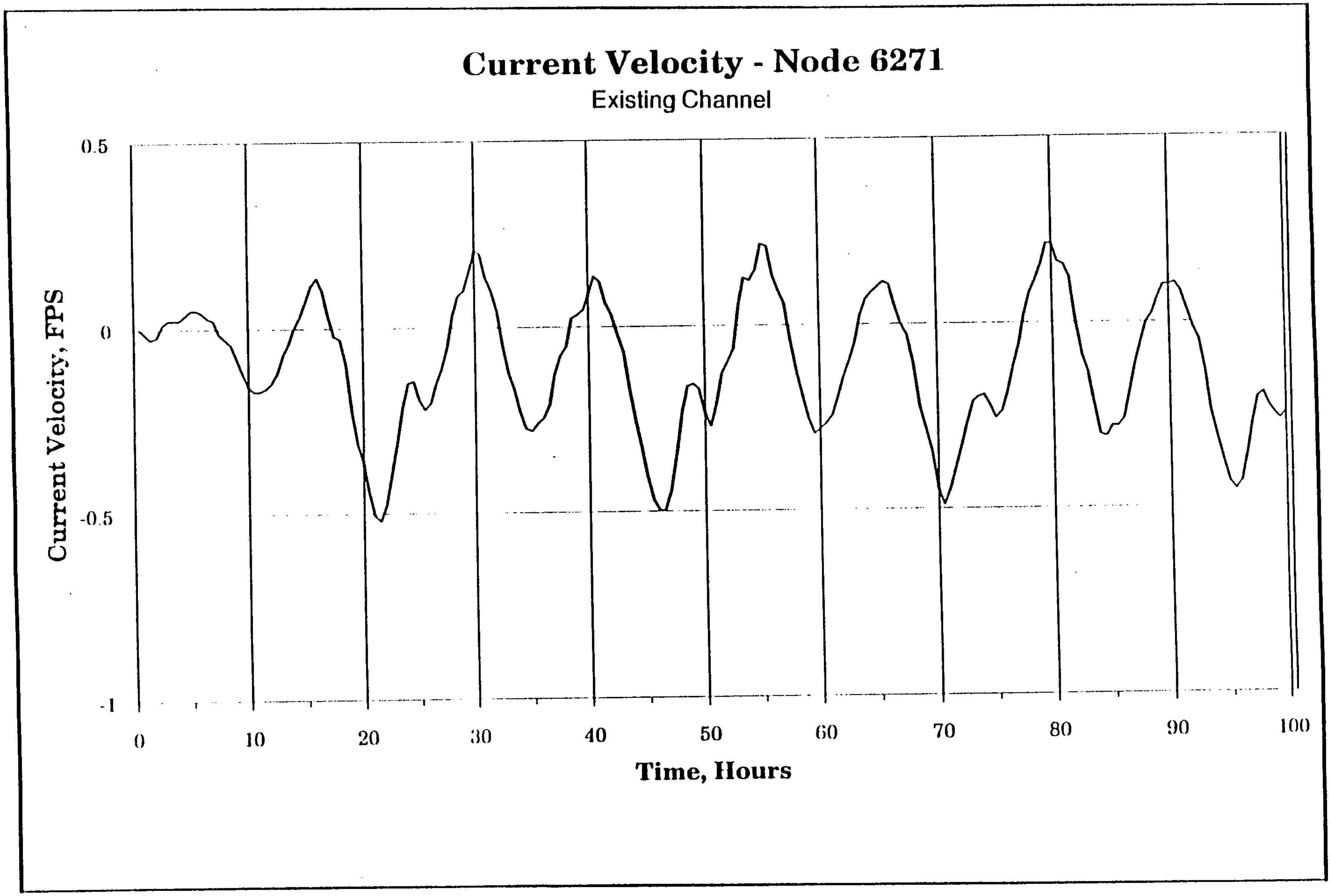

Current Velocity - Node 6271
Existing Channel
Current Velocity, FPS
0.5
0
-0.5
-1
0
10
20
30
40
50
60
70
80
90
100
Time, Hours

Figure 16

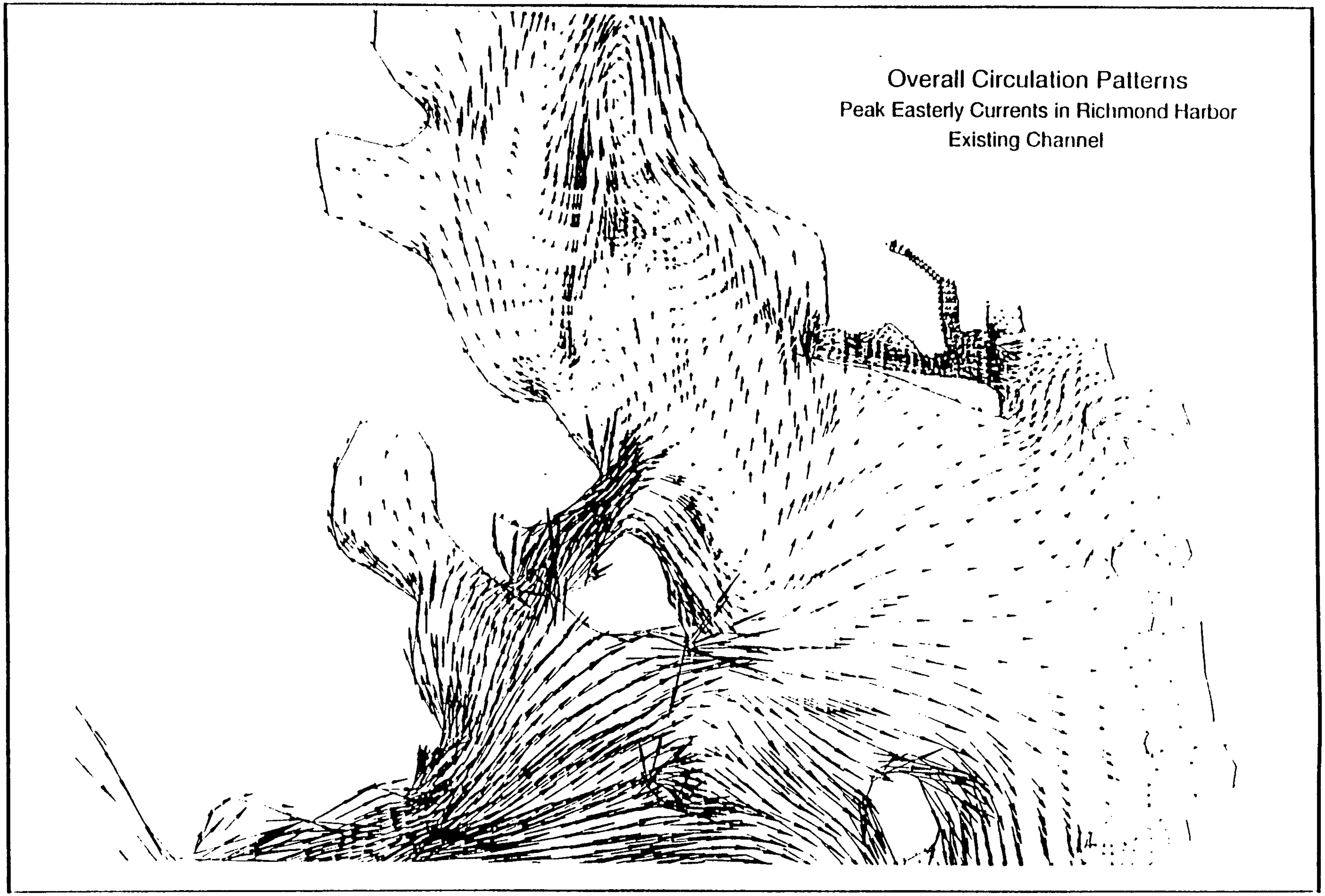

Overall Circulation Patterns
Peak Easterly Currents in Richmond Harbor
Existing Channel

Figure 17

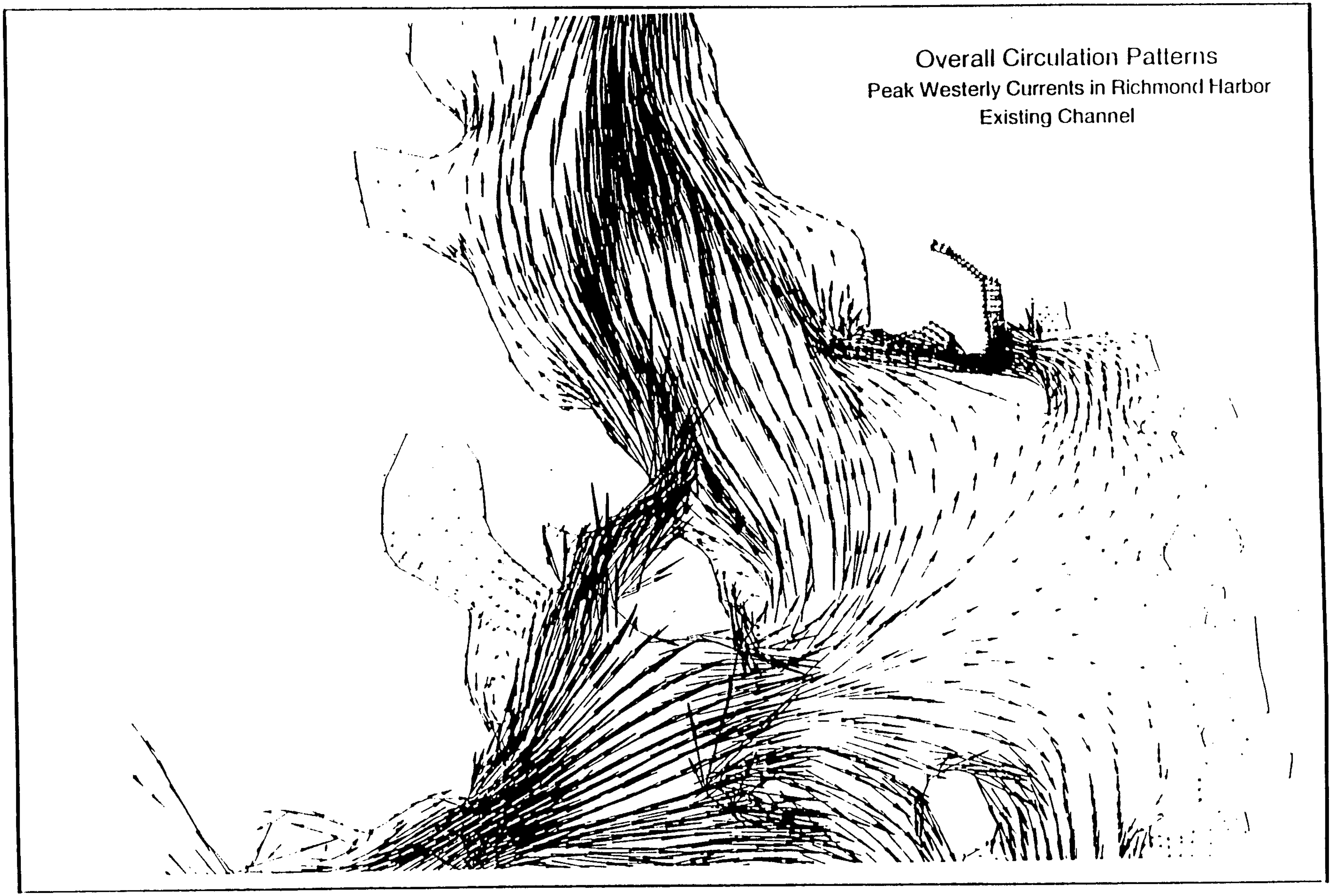

Overall Circulation Patterns
Peak Westerly Currents in Richmond Harbor
Existing Channel

Figure 18

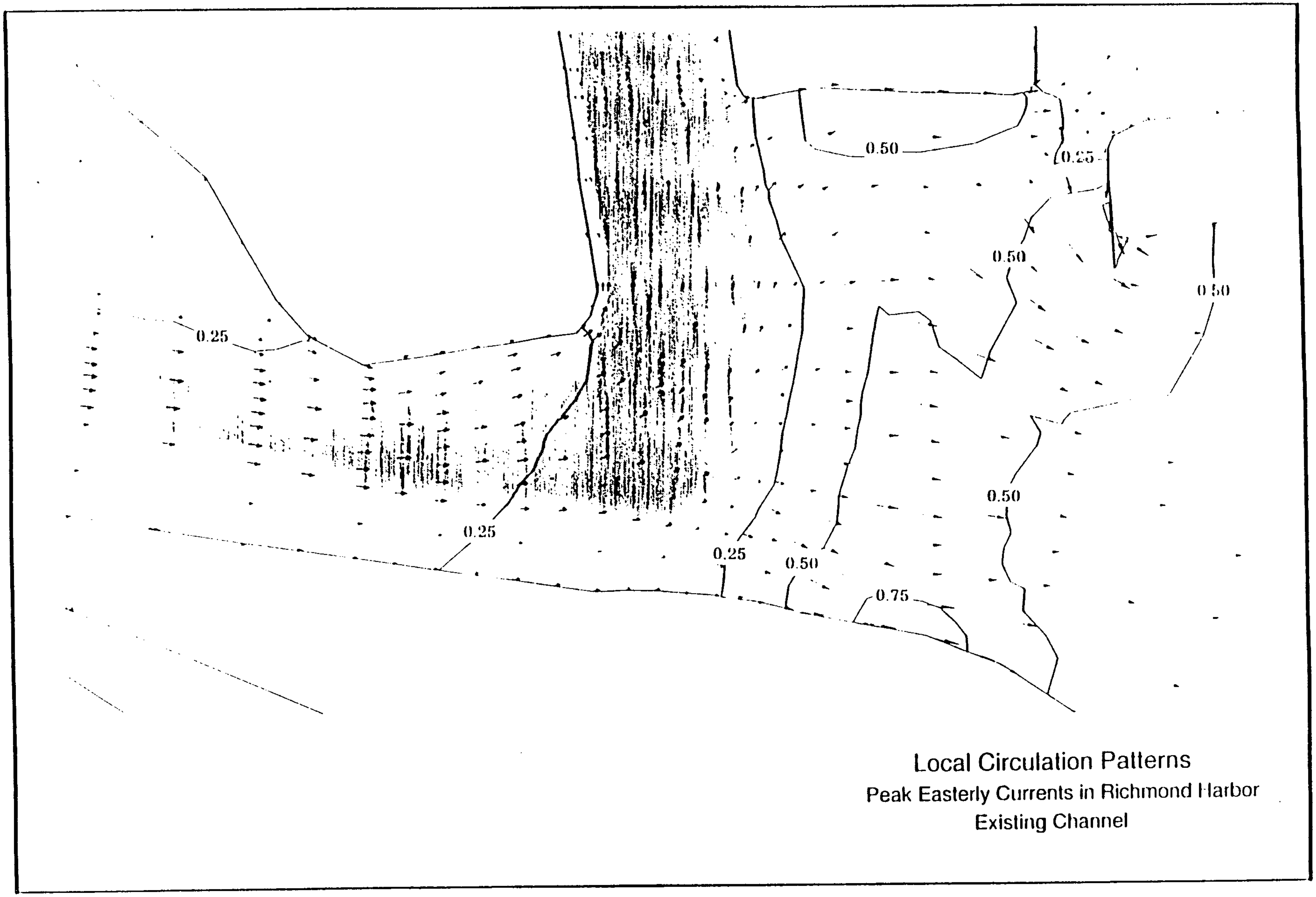
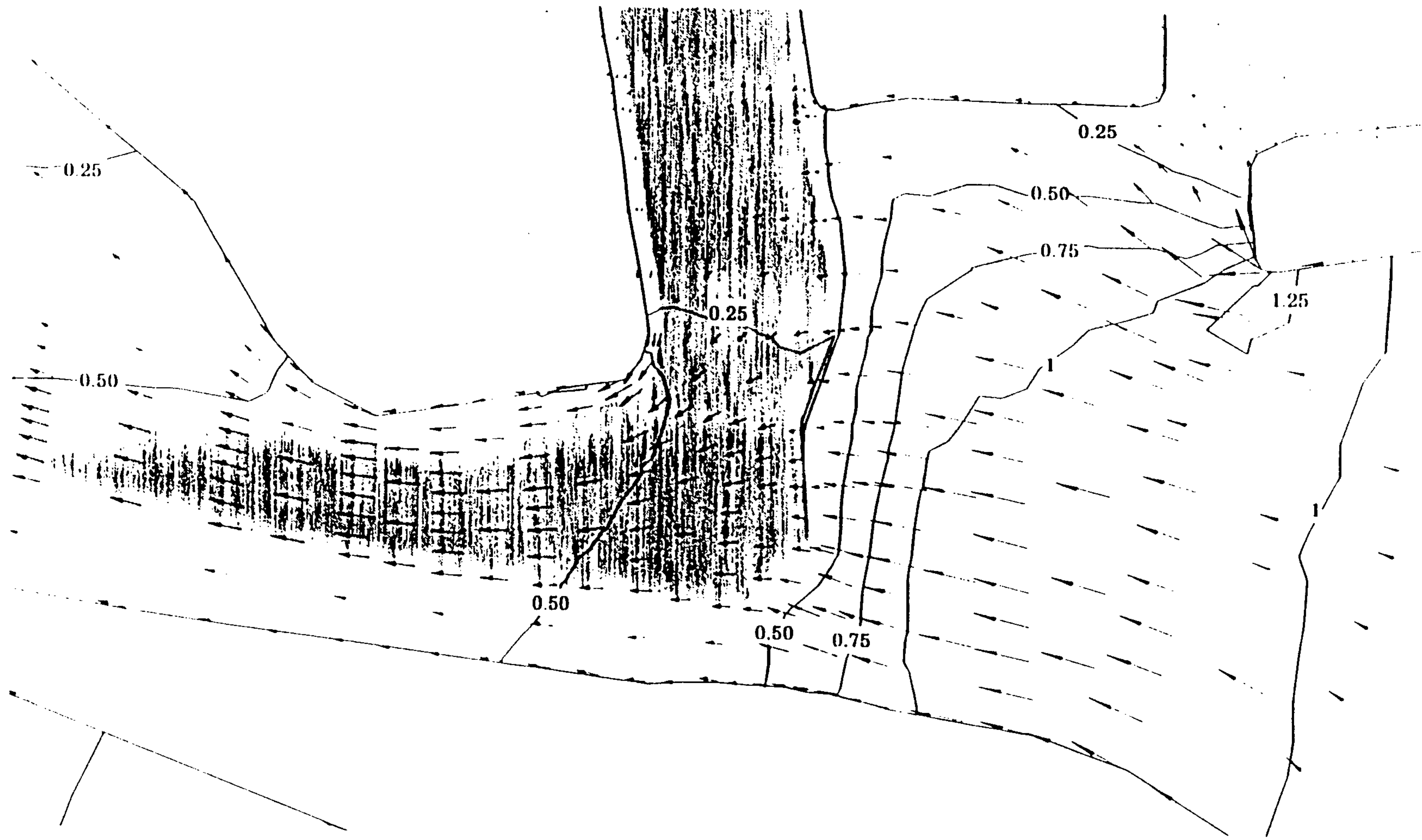

0.50
0.25
0.50
0.50
0.25
0.25
0.50
0.25
0.25
0.50
0.75
Local Circulation Patterns
Peak Easterly Currents in Richmond Harbor
Existing Channel

Figure 19



Local Circulation Patterns
Peak Westerly Currents in Richmond Harbor
Existing Channel

Figure 20

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199

REPLY TO ATTENTION OF

CEWES-HN

20 June 1996

MEMORANDUM FOR Commander, U.S. Army Engineer District, San Francisco, ATTN: CESPN-PM/Mr. Jacob Harari, 211 Main Street, San Francisco, CA 94105-1905

SUBJECT: Richmond Harbor Navigation Studies

1. As discussed in telephone calls between Dr. Larry Daggett, CEWES-HN, and Mr. Jacob Harari, CESPN-PM, in March and June 1996, we have reviewed the conclusions and recommendations resulting from the navigation studies of the proposed Richmond Harbor improvements. The results of three navigation studies were reported in three different reports:

a. Preliminary Findings Report on Richmond Harbor Ship Simulation Tests, 17 September 1987.

b. Desk Top Study Report for Richmond Harbor Deepening, Santa Fe Channel Segment, 27 November 1989.

c. Richmond Harbor Turning Basin, 3 February 1995.

2. Based on this review, we still support the conclusions and the recommendations. The Richmond Harbor Turning Basin recommendations should supersede the 1987 recommendations. Please direct any questions concerning this to Mr. Carl Huval or Dr. Larry Daggett at 601-634-2614 or -2259, respectively.

FOR THE DIRECTOR:

Richard A. Sager

RICHARD A. SAGER
Acting Director, Hydraulics Laboratory

Appendix C

Real Estate Plan

APPENDIX C

REAL ESTATE PLAN

RICHMOND HARBOR NAVIGATION IMPROVEMENT PROJECT

GENERAL INFORMATION

This appendix represents the real estate requirements for the Richmond Harbor Navigation Improvement Project. This project's purpose is to create a safe, deep-draft navigation channel of sufficient depth for modern deep-draft carriers that are scheduled to use the Port of Richmond terminal facilities. Construction of the Richmond Harbor Deepening Project was authorized by the Water Resources Development Act (WRDA) of 1986, 99th Congress, 2nd Session, Public Law 99-662.

GENERAL DESCRIPTION OF THE AREA, PROECT, AND TOTAL ACREAGE TO BE ACQUIRED

The project is located at Richmond Harbor in Richmond, California. Richmond is a major port resulting from a combination of favorable geographical features such as being conveniently located on San Francisco Bay with large areas of level land and deep water close to the shoreline. Richmond is located in Contra Costa County which is one of the nine Counties that make up the Bay Area. Contra Costa has one of the highest growth rates of the Bay Area Counties. Richmond Harbor, located at the Port of Richmond, is located on the eastern shore of San Francisco Bay, about six miles northwest of the eastern entrance to the Bay Bridge. The Harbor area consists of the Harbor Entrance Channel, Potrero Reach Channel, Potrero Turning Basin, Inner Harbor Channel, and Santa Fe Channel. The project begins at the end of the Richmond Long Wharf Maneuvering Area and extends four nautical miles from the Harbor Entrance Channel to the Santa Fe Channel (600 feet northwest, beyond the Lauritzen Channel).

The project consists of deepening the existing 4.0 nautical miles of the Richmond Harbor Channel from -35 feet Mean Lower Low Water (MLLW) to -38 feet MLLW. The project is a two-phase channel improvement plan, Phase I and Phase II. Phase I of the project is designed for bulk vessels (-38 feet MLLW). Phase II will be designed for containerships (-41 feet MLLW). Phase II has been deferred indefinitely. This Real Estate Plan is, therefore, only addressing Phase I. In addition to the deepening of the channel, the project will also provide a 1,200-foot diameter turning basin at Point Potrero and dispose of 1.91 million cubic yards (MCY) of material. The dredged material considered unsuitable for unrestricted disposal, consisting of approximately 234,000 cubic yards (CY), will be disposed of at the Parking Lot area near Point Potrero. This 50.09-acre parking lot disposal site is

the subject of this report. There are no other real estate requirements for this project.

The real estate requirements for the recommended plan of improvement for Richmond Harbor is to provide a disposal site for dredged material and consists of a temporary work area easement for one year for the three areas described as follows:

Area 1 - 300,000-square-foot area for drying material *
Area 2 - 8.28-acre receiving area
Area 3 - 1.87 acres that includes Basin 1 of the graving docks

*An access roadway described as 100,240 square feet in area will be used to replace the existing access to Terminal 5 for the entire one-year construction period and is included in Area 3.

(See Figure 15 in the GDM for better clarification of these areas.)

The dredged material placement plan requires the material to be dredged by clamshell dredge and brought in by barge through Basin 1 (Area 3), deposited in Area 2 for dewatering and aeration, and then placed in the 300,000 square-foot area (Area 1) for additional drying.

The mitigation concerns in this project consist of dredged material unsuitable for aquatic and wetland disposal, eelgrass beds, the presence of endangered bird species, the winter-run chinook salmon migration paths, possible emission affecting air quality, and the Noise Element resulting from dredging. All of these concerns have been addressed and responded to in the overall consideration of this project and are reflected in the General Design Memorandum (GDM). There are no wildlife and environmental mitigation lands or wetland mitigation enhancement areas required. The parking lot disposal site discussed in this report is the mitigation for the dredged material that is unsuitable for other disposal.

There is no federally owned land in this area. The Port of Richmond purchased the property discussed in this report from the Maritime Commission in 1968.

Navigation servitude applies to this project, since it is a Federal channel. However, there are no navigation servitude issues in this project.

PUBLIC LAW (PL 91-646) RELOCATIONS

There are no relocations included in this project as required by PL 91-646.

SPONSOR'S ABILITY TO ACQUIRE

The non-Federal sponsor is the City of Richmond. The sponsor does not have a real estate staff. All property required however, is owned by the sponsor. Their present staff has the ability to process the real estate requirements.

ESTATES

The non-Federal sponsor will acquire the minimum interests in real estate which will support the construction and subsequent operation and maintenance of the project. As stated and described earlier in this report, the estate for this project is the standard estate, Temporary Work Area Easement (TWAE) for one year.

BASELINE COST ESTIMATE

The non-Federal sponsor prepared their respective estimates of acquisition costs and schedules based on their knowledge of project requirements and anticipated staffing and resource levels. The Appraisal Branch of the Sacramento District Real Estate Division prepared the gross appraisal upon which the land cost estimates are based. All lands, regardless of ownership, have been estimated at fair market value. The baseline cost estimate is as follows:

Baseline Cost Estimate for Real Estate

Project	Non-Federal	Federal	Lands* (LERRDS)	Project Total
Richmond Harbor	$15,000	$89,100	$1,210,000	$1,314,100
Total	$15,000	$89,100	$1,210,000	$1,314,000

* Includes lands, damages, contingencies and PL 91-646 relocations.

PROJECT MAP

The project map consists of Plates 1-5 and Figure 15 in the GDM.

MINERALS

There are no valuable minerals impacted by this project. There was, therefore, no enhancement for mineral deposits included in the baseline cost estimate.

ACQUISITION SCHEDULE

A detailed acquisition schedule is attached as Exhibit A. Schedule A depicts a schedule for land acquisition that would not normally be feasible. This schedule has been discussed and planned for. The justification for this schedule is that there are no acquisitions required. The non-Federal sponsor owns the property required for this project. They have agreed to have the necessary documents available to certify upon the execution of the Project Cooperation Agreement and immediately execute the Authorization for Entry and the Attorney's Certificate As To Authorization for Entry concurrently. Since the real estate requirements are so minimal, not much time will be required for certification of the real estate by the Real Estate Division to meet the advertisement for construction date.

FACILITY AND UTILITY RELOCATIONS

There are no facility or utility relocations to be accomplished for the Federal project.

HAZARDOUS, TOXIC, AND RADIOLOGICAL WASTE

The parking lot area where the 300,000 square-foot portion of the disposal site (Area 1) is located is contaminated with asbestos. The sponsor has been required to remediate for this by the State of California and currently has a plan to do so. The other areas required for real estate, Areas 2 and 3, are not contaminated. The Lauritzen Channel has contamination, but there are no real estate requirements in this channel.

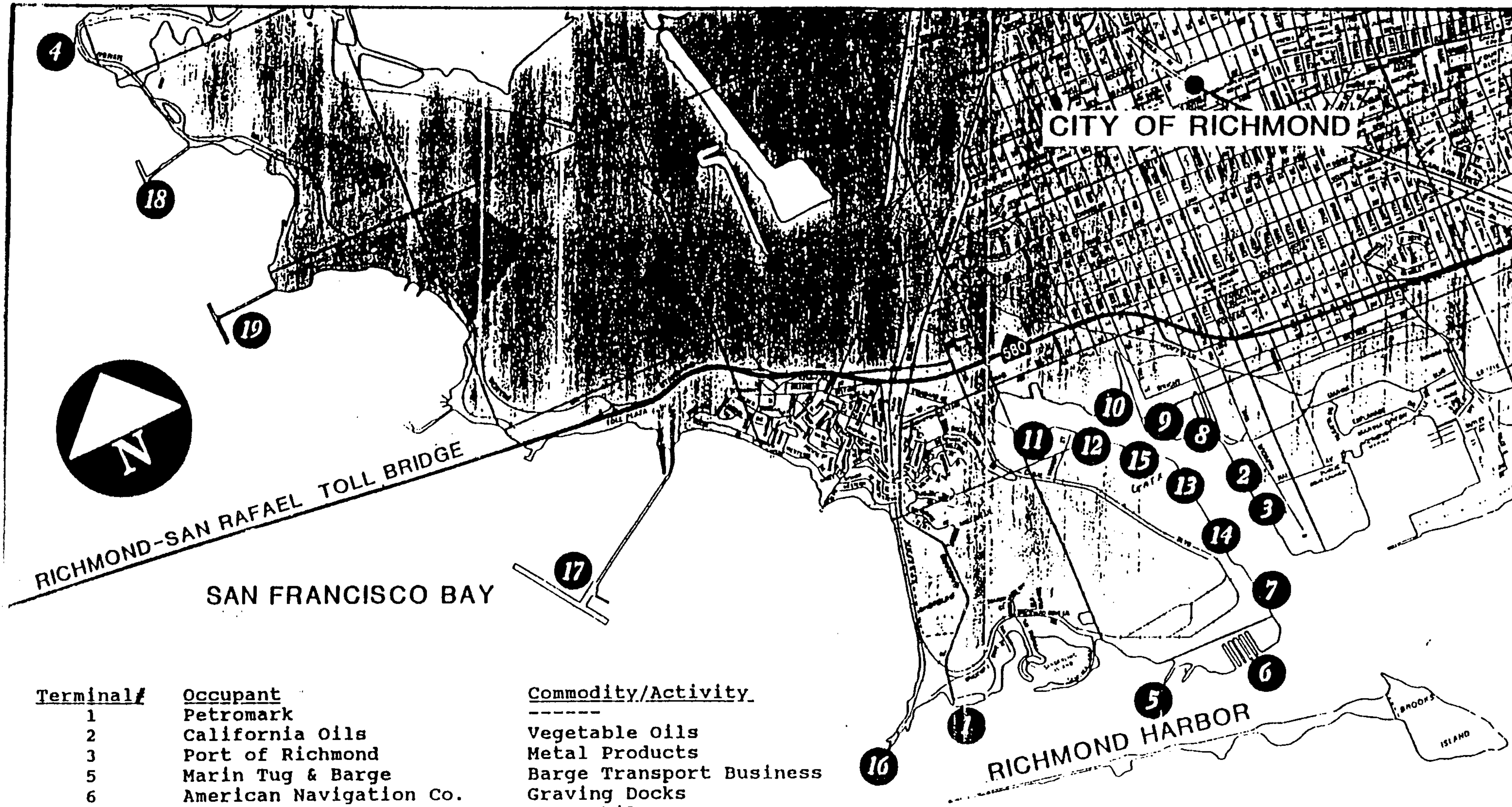
The appraiser considered the asbestos contamination in his valuation; however the contamination did not affect his value conclusion. The non-Federal sponsor will assume complete financial responsibility for the cleanup of any hazardous material located on the project lands and regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and be responsible for operating, maintaining, repairing, replacing, and rehabilitating the project in a manner so that liability will not arise under CERCLA.

EXHIBIT A

REAL ESTATE MILESTONES				
PROJECT	**COE START**	**COE FINISH**	**NFS START**	**NFS FINISH**
Execution of PCA		07/96		07/96
Formal transmittal of final ROW drawings & instruction to acquire LERRDS		07/96		
Conduct landowner meetings			N/A	N/A
Prepare/review mapping & legal descriptions			07/96	07/96
Obtain/review title evidence			07/96	07/96
Obtain/review tract appraisals			N/A	N/A
Conduct negotiations			N/A	N/A
Perform closings			N/A	N/A
Prepare/review condemnations		N/A		N/A
Perform condemnations		N/A		N/A
Obtain possession		N/A		N/A
Complete/review PL 91-646 benefit relocations		N/A		N/A
Conduct/review facility & utility relocations		N/A		N/A
Certify all necessary LERRDS are available for construction	07/96	08/96		
Prepare and submit credit requests			10/96	12/96
Review/approve or deny credit requests	12/96	02/97		
Establish value for creditable LERRD in F&A cost accounting system	02/97	06/97		

Appendix D

Economic Analysis



Terminal#	Occupant	Commodity/Activity
1	Petromark	------
2	California Oils	Vegetable Oils
3	Port of Richmond	Metal Products
5	Marin Tug & Barge	Barge Transport Business
6	American Navigation Co.	Graving Docks
7	Pasha Group	Automobiles
8	Time Oil	Petroleum Products
9	Levin-Richmond	Scrap Metal & Dry Bulk
10	Texaco	Petroleum Products
12	Santa Fe Dock	(No Activity)
13	UNOCAL	Petroleum Products
	GATX	Liquid Bulk
14	Atlantic Richfield(ARCO)	Petroleum Products,Jet Fuel
15	Gold Bond Building Products	Gypsum Rock
16	Santa Fe Ferry	(No Present Service)

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CONTRA COSTA COUNTY CALIFORNIA

RICHMOND HARBOR 38-FOOT PROJECT
PHASE I

ECONOMIC BENEFITS
LOCATION MAP

IN SHEET SHEET NO
U.S. ARMY ENGINEER DIST., SAN FRANCISCO C OF E
DRAWN FILE NO
TRACED TO ACCOMPANY REPORT
CHECKED DATED

FIGURE 1

RICHMOND INNER HARBOR PROJECT
ECONOMIC EVALUATION OF PROJECT BENEFITS
FEBRUARY 1996

I. Summary

Purpose and Scope:

The purpose of this economic analysis is to develop an estimate of the National Economic Development (NED) benefits for the proposed Richmond Inner Harbor Project and to present the methodology for determining these benefits. The project benefits are in the form of transportation savings resulting from the deepening of the Richmond Inner Harbor Channels.

This economic evaluation describes the benefits for primarily one alternative, a 38-foot channel, as the "project condition." This is both the locally preferred plan and the National Economic Development (NED) plan. However, the Army Corps of Engineers has examined the costs and benefits associated with alternative depths between 36 and 40 feet in order to optimize the project. Thus, while all depths between 36 and 40 feet have been evaluated, the focus is on the 38-foot project for expository purposes and completeness. A listing of the project benefits for each alternative appears in Table 11.

Major Findings:

The overall benefits to the 38-foot project have been calculated to be $4.5 million in average annual equivalent terms. The benefits for the other alternatives range from $3.2 million to $5.4 million. Based on annual costs ranging from $2.1 million to $4.6 million, the 38-foot project maximizes net benefits, which are approximately $1.8 million. Fifty-five percent of the benefits will be reaped by dry bulk and scrap metal industries, while 45% will be divided among the liquid bulk, petroleum products and automobile industries.

Study Area:

The Richmond Inner Harbor study area consists of the harbor entrance, the Potrero Reach, the Inner Harbor, and the Santa Fe Channels. The terminals considered in this study include the city-owned public terminals 1 through 7, and privately owned terminals 8 through 16, with the exception of terminals 4, 11, and 12, which are located outside of the proposed project area. Figure 1 shows the locations from which economic benefits are created through channel deepening.

II. Background

Cargo Volume:

Over the past several years, the tonnage in Richmond Harbor has increased markedly, from 2,822,000 short tons in 1986 to 4,212,000 short tons in 1994 (Table 1). According to a report prepared by Manalytics Inc., these increases are projected to continue well into the 21st century[1].

Types of Commodities:

The various commodities handled by the terminals were grouped into the following categories shown below:

- Liquid Bulk: vegetable oil, coconut oil, palm oil, safflower oil, olive oil, caustic soda, toluene
- Dry Bulk: cement, steel coils, coke, bauxite, silicon manganese ore, chrome ore, flat iron, gypsum rock
- Petroleum Products: diesel fuel, methanol, asphalt, jet fuel, gasoline
- Scrap Metals
- Automobiles

III. Transportation Savings Methodology

The transportation savings can be derived by comparing the difference in the estimated costs for vessel opertations under "with" and "without project" conditions. The "without" project condition is the currently authorized -35 foot MLLW channel. The "with" project conditions are the incremental alternative channel depths between -36 and -40 feet MLLW. A deeper channel allows larger vessels to use the harbor, resulting in increased tonnages carried and lower unit costs. In addition, a deeper channel shortens the time needed for vessels to maintain proper clearance. This also lowers sea and port costs.

Operating Costs:

Estimates of operating costs for bulk carriers and tankers were furnished by the Office of the Chief of Engineers' (OCE) FY–1995 Planning Guidance Deep Draft Vessel Costs. This guidance is used by Corps of Engineers planners in studies detemining the potential benefits of harbor improvement projects. As seen in Appendix A, the cost to operate a foreign flag bulk

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[1] *Source: San Francisco Bay Area Cargo Forecast to 2020 and the Future Demand for Marine Cargo Terminals Manalytics Inc., October 1988*

Table 1
Richmond Inner Harbor Project
Tonnage History (1987-1994)

Company	Commodity	1987	1988	1989	1990	1991	1992	1993	1994
Petromark	Liquid Bulk[1]	140,737	27,704						
Calif Oils	Liquid Bulk	113,314	99,017	78,058	85,223	77,678	101,104	76,964	79,991
Calif Steve. & B	Break Bulk	149,602	102,257	92,589	152,213	137,602	226,065	134,347	237,122
Pasha	Autos	126,701	132,289	149,778	152,854	142,039	118,780	102,744	103,927
Time Oil	Petro Products	278,184	212,381	171,164	132,767	336,055	305,992	283,813	255,148
Levin	Dry Bulk	549,368	654,674	637,127	738,030	505,772	416,208	425,558	524,292
	Scrap Metal	400,986	258,668	257,911	316,299	249,111	244,437	284,465	349,528
Texaco	Petro Products	793,663	858,011	786,000	983,082	1,147,203	897,085	841,626	936,254
Unitank	Liquid Bulk	79,287	221,464	237,663	314,500	307,508	290,204	307,340	253,031
Union Oil	Petro Products	103,517	82,420	25,310	31,404	24,626	15,547	62,680	52,169
ARCO	Petro Products	252,604	392,960	492,061	384,237	772,098	909,538	1,520,532	1,244,570
Gold Bond	Gypsum Rock	194,484	198,925	166,581	199,185	153,809	169,812	81,260	175,937
Total		3,182,447	3,240,770	3,094,242	3,489,794	3,853,501	3,694,772	4,121,329	4,211,969
Percent Change			1.8%	-4.5%	12.8%	10.4%	-4.1%	11.5%	2.2%
Total Percent Change ('87-'94)									32.35%

[1] Tonnage handled from Jan through Apr 1988 only.

accommodate the increased volume. In addition, the future tonnages are dependent on the composition of tankers, which are expected to change throughout the next 50 years. For example, in 1988, 9% of the parcel tankers had maximum DWT of 40,000. By 2035, this percentage is expected to reach 20%. For U.S. flag tankers, a similar trend is expected. The compositions and projected tonnages for parcel and U.S. flag tankers are shown in Appendix E.

Transportation Cost Savings:

Transportation costs and the corresponding unit cargo costs for various sizes of vessels were calculated under with and without project conditions. Additional costs for time spent in port and charges for various services incurred by the vessels were not computed into the transportation costs. The additional costs such as tug assistance, loading, and pilotage are assumed to continue to accrue as in pre-project conditions. The hours in port represent the total number of hours spent in port at both Richmond and the harbor of origin/destination. We considered the time spent at the port of origin/destination to be the same as the time spent in Richmond.

Richmond Harbor is presently -35 feet deep MLLW. A minimum of 4 feet was maintained for underkeel clearance consisting of 1 foot trim, 1 foot squat and 2 feet safety. The underkeel clearance was based on observed shipping practices in the area and through personal conversations with various shippers. Vessels with drafts of 31 feet or more were considered in the analysis. Vessels were grouped by their sizes and transportation costs and were calculated and compared among vessels of the same size. For some commodities such as scrap metal, there are two vessels used. Thus, two sets of unit costs and benefits were determined. An example of the method used to determine the transportation costs is presented in below for a foreign-flag bulk carrier of 40,000 DWT transporting coke to Vladivostok, Russia.[2]

In this example, the vessel has a 38-foot operating draft, and is leaving the 35-foot harbor 2-feet light-loaded under the without project condition. Under "with" project conditions, the vessel is leaving fully loaded.

WITHOUT PROJECT CONDITIONS:

round-trip distance *speed*

Time at sea - 9126 miles at 14 knots/hr = 652 hours

Cost at sea, 652 hours at $582/hr = $379,464

Capacity 40,000 short tons ← *ship's max. DWT*

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[2] These calculations are for the 38-foot project. Similar calculations were performed for alternative depths and appear in the tables following those used for the 38-foot project.

Max. Draft 38 feet

This vessel, utilizing 5 feet of tide in the 35-foot harbor to maintain underkeel clearance, must leave the harbor two feet light-loaded. (35 foot harbor plus 5 feet of tides minus 4 feet underkeel clearance equals 36 foot conditions). The volume of cargo which comprises two feet of cargo space can be estimated by using the known immersion factor of 117 long tons per inch specific to this vessel.

immersion factor *conversion to short tons*

40,000 short tons – (117 long tons/inch x 2,240 lb/long tons ÷ 2,000 lb/short tons) × 12 inches × 2 ft = 40,000 – 4717 = 35,283 short tons ← *amount ship can actually carry*

amount light loaded

Unit cost at sea = $379,464/35,283 short tons = $10.75 per short ton

Cost at Port

(192 hrs) × ($479/hr) / 35,283 short tons = $2.60 per short ton

Total Unit Cost

$10.75 + $2.60 = $13.35 per short ton

WITH PROJECT CONDITIONS:

Cost at Sea

round trip distance *speed*

Time at sea - 9126 miles at 14 knots = 652 hours

Total cost at sea - 652 hours at $582/hr = $379,464

Tons carried 40,000 short tons

Unit cost at sea = $379,464/40,000 short tons = $9.49 per short ton

Cost at Port

(192 hrs) × ($479/hr) / 40,000 short tons = $2.30 per short ton

Total Cost With Project

$9.49 + $2.30 = $11.79/short ton

Savings Per Ton

$13.35 - $11.79 = $1.56/short ton

Types of Benefits:

Economies of Scale generally occur when vessels increase their carrying capacities. Presently, many shipping companies would like to use larger vessels to transport their cargo, but are constrained due to shallow channel depths. A deeper channel allows a shipper to use larger, deeper draft vessels. With larger vessels, the operating costs of a larger vessel would be outweighed by the additional cargo capacity. The large carrying capacity reduces the cargo's cost per ton by allowing more cargo to be transported per trip. An analysis of the ports of origin and destination was made for the five commodities expected to undergo economies of scale. All foreign ports of entry/destination, with the exception of a Mexican port, are at least 40 feet deep and can accommodate the projected tonnages.

Light Loading Practices generally refer to vessels unable to enter or exit the channel fully-loaded. The depth of the channel limits the operating draft of the vessel which in turn limits the vessel's load. When entering the channel, the vessels must either light-load before entry or top-off at other harbors to reduce their load. With a deeper channel, vessels can load more fully. A larger load distributes the fixed operating costs over a larger volume to reduce the cargo's cost per ton. Appendix H summarizes the benefits by light loading and economies of scale.

Tidal delay reduction benefits can be defined as the time savings brought on by shorter and fewer delays. Richmond Harbor is presently -35 feet deep MLLW. Once again, a minimum of 4 feet is maintained for underkeel clearance consisting of 1 foot trim, 1 foot squat and 2 feet safety. Therefore, all vessels with a operating draft of 31 feet or more must wait for tides to maintain the 4-foot underkeel clearance. Under project conditions, vessels with drafts of 31 to 34 feet can enter safely without waiting. The tidal delay benefit results from eliminating or reducing the time spent waiting for a tide. The costs per foot of tidal delay are computed using the following equation:

(Probability of having to wait for a tide) × *(Ave. Duration of waiting time)*
× *(Cost of wait per hour)* = *Total Cost of Tidal Delays*

Duration of waiting time is the average waiting time to account for vessels arriving at any point along the curve shown in Figure 2. The probabilities of having to wait for a tide also appear along side the curve. Suppose a vegetable oil parcel carrier is facing a 2-foot tidal delay without a 38- foot project. The savings in tidal delays then can be calculated as follows:

2 feet of delay = 6 hours
(6 hours)/2 × (0.242) × ($737) = $535

The delay cost per hour is defined as the average of the cost at sea and at port. For this analysis, three sets of costs were used for vessels between 25,000 and 40,000 DWT. These are for U.S. Petroleum/Jet Fuel Double-Hulled Tankers, Parcel Tankers, and for the Bulk Carriers (all other commodities).

Petroleum/Jet Fuel -- U.S. Flag Double-Hulled Tankers

Average hourly sea cost	$1,706	for tankers ranging in size from 25,000 to 40,000 DWT
Average hourly port cost	$1,612	

Vegetable Oils-- Parcel Tankers

Average hourly sea cost	$844	for tankers ranging in size from 25,000 to 40,000 DWT
Average hourly port cost	$630	

All Other Commodities

Average hourly sea cost	$538	for bulk vessels ranging in size from 25,000 to 40,000 DWT

Cost of Tidal Delay by Foot

	Average Tidal Delay	Petroleum/ Jet Fuel	Vegetable Oils	All Others
1 Foot	0.32 hours	$534	$237	$158
2 Feet	0.73 hours	$1,204	$535	$356
3 Feet	1.5 hours	$2,483	$1,107	$736
4 Feet	2.6 hours	$4,273	$1,901	$1,264
5 Feet	9.3 hours	$15,444	$6,854	$4,557

Tidal delay benefits are realized only where deepening the channel will reduce or eliminate costs associated with tidal delays. Many vessels, particularly those which will increase shipping capacities, will continue to face tidal delays even with a deeper harbor.

Once tidal delay costs were developed for the 38-foot project, the tidal delay depths were adjusted by the number of feet altered by each project alternative. For instance, at 38-foot project depths, cement vessels with 37-feet drafts can expect 3-feet tidal delays. At 39 feet, the delay will be 2 feet. Alternatively at 37 feet, the delay will be 4 feet. The number of vessel trips and the size of vessels remained the same regardless of project alternative.

Decadal Factors:

The decadal factors developed by the San Francisco District area are a mathematical tool used to approximate annualized values by using specific decade values with increasing series. They were used to calculate the annualized benefits for the Richmond Inner Harbor. The formulas on the left determined the decadal factors at the present federal discount interest rate (i) of 7⅝ percent and the assumed project life of 50 years. The results are listed on the right.

Formulas	Factors
Base Year: $K_o = \left[\frac{i\,(1+i)^{50}}{(1+i)^{-50}} \right] \times \left[\frac{(1+i)^{-10}}{2i\,(1+i)^{10}} \right]$	Base Year (K_o) = 0.28293
1st Decade: $K_1 = 1 + 1/(1+i)^{10}$	1st Decade (K_1) = 0.41862
2nd Decade: $K_2 = K_1\,(1+i)^{-10}$	2nd Decade (K_2) = 0.20077
3rd Decade: $K_3 = K_1\,(1+i)^{-20}$	3rd Decade (K_3) = 0.09629
4th Decade: $K_4 = K_1\,(1+i)^{-30}$	4th Decade (K_4) = 0.04618
5th Decade: $K_5 = K_1\,(1+i)^{-40}$	5th Decade (K_5) = 0.02215

These decadal factors were multiplied to the savings derived from subtracting the transportation costs with-project conditions from those without-project-conditions. The average annual benefits then for a particular terminal (or commodity) are the sum of each savings.

IV. Benefit Calculations

The benefits by commodity are presented for the 38-foot project alternative. Similar analyses were performed for alternative project depths and appear in tables at the end of this appendix.

Liquid Bulk

The liquid bulk handled at Richmond Inner Harbor includes vegetable oils, palm oil, safflower oil, animal fats, caustic soda and toluene. These bulk liquids originate from the Far East and are transported in parcel tankers which typically call at two or three Richmond terminals. Petromark, Calif. Oils, and UNOCAL operate at terminals 1,2, and 13, respectively.

Vegetable Oils:

A) Terminal 1

Petromark Inc., which suspended waterborne cargo operations in 1988, had shipped vegetable oils, chemicals, animal fats and petrochemicals from Korea and Japan. This tonnage was carried in vessels with design drafts ranging from 31 to 38 feet. In 1987, the tonnage handled was 140,737 short tons. Because Petromark closed in April 1988, 1987 was used as a base year to project future tonnages. Conversations with the Port indicate a new tenant will have undertaken vessel operations at this terminal once a deepening project is completed.

B) Terminal 2

California Oils Company handles vegetable oils only. In 1988, the operation received 34 vessels which transport crude and semi-refined coconut oil, palm oil, and safflower oil to the terminal. The company imports these oils from the Philippines, Malaysia, Indonesia and Micronesia. According to an August 1988 edition of "Pacific Shipper's Focus on Port of Richmond," the Port of Richmond is usually the first port of call from these origins.

This company uses foreign parcel tankers ranging in size from 8,755 to 37,000 DWT with design drafts of 22 to 38 feet. The operating drafts range from 21 to 37 feet. The average time spent in port is 1 to 3 days.

C) Terminal 13

Two companies, UNOCAL and GATX, share this terminal. No benefits were calculated for UNOCAL since it uses shallow-draft barges and pipelines to transport petroleum products. Interviews with UNOCAL's representatives confirm that the deepening project would not change its operations.

In 1988, GATX used 49 parcel tankers to transport 221,464 short tons of caustic soda, toluene, and coconut oil from the Far East. The size of vessels ranged from 17,000 to 40,000 DWT and had design drafts of 32 to 38 feet. The average time spent in port was one day. The total sea (port) costs are costs per hour at sea (in port) multiplied by the time spent at sea (in port) Table 3a shows the sea and port cost derivations for the four types of vessels.

Table 3a-- Vegetable Oils
Richmond Inner Harbor Project
Sea/Port Cost Calculations

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
17000	32'	14,000	14	1000	$722	$722,000	24	$567	$13,608
25000	35'	14,000	14	1000	$786	$786,000	24	$604	$14,496
35000	37'	14,000	16	875	$858	$750,750	24	$635	$15,240
40000	38'	14,000	16	875	$889	$777,875	24	$649	$15,576

Table 3b presents the unit cost derivations for the with and without project conditions. A vessel with a DWT of 40,000 and an operating draft of 38 feet must light load by two feet, an amount equivalent to 3,279 tons of cargo. At the same time, a vessel with a DWT of 35,000 and an operating draft of 37 feet must light load by one foot, an amount equivalent to 1,505 tons of cargo. Under 38-foot project conditions, both vessels can load fully. The unit costs for the 40,000 DWT vessel decreased from $21.61 to 19.84/ton while the unit costs for the 35,000 DWT vessel decreased from $22.87 to $21.89/ton.

Table 3b--Vegetable Oils
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Light Load (ft)	Tons Lt Load	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
17000	32'	0	0	17,000	$42.47	$0.80	$43.27
25000	35'	0	0	25,000	$31.44	$0.58	$32.02
35000	37'	1	1,505	33,495	$22.41	$0.45	$22.87
40000	38'	2	3,279	36,721	$21.18	$0.42	$21.61

With Project Conditions

DWT	Max Des. Draft	Light Load (ft)	Tons Lt Load	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
17000	32'	0	0	17,000	$42.47	$0.80	$43.27
25000	35'	0	0	25,000	$31.44	$0.58	$32.02
35000	37'	0	0	35,000	$21.45	$0.44	$21.89
40000	38'	0	0	40,000	$19.45	$0.39	$19.84

The total unit costs for the with and without project conditions were multiplied by the

expected tonnages in determining the total operating costs (Table 3c). The benefits are the savings in operating costs as a result of the project. This reduction in light loading yields average annualized benefits of $991,000.

Table 3c--Vegetable Oils
Richmond Inner Harbor Project
Benefit Calculations

Without Project Conditions

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
17000	$43.27	$10,341,337	$10,079,165	$9,702,359	$9,193,708	$9,193,708	$9,193,708
25000	$32.02	$3,826,319	$4,143,682	$4,487,369	$4,859,562	$4,859,562	$4,859,562
35000	$22.87	$1,639,675	$1,775,674	$2,536,936	$3,470,744	$3,470,744	$3,470,744
40000	$21.61	$1,032,832	$1,677,746	$1,816,902	$1,967,600	$1,967,600	$1,967,600
	Totals	$16,840,163	$17,676,267	$18,570,566	$19,491,614	$19,491,614	$19,491,614

With Project Conditions

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
17000	$43.27	$9,307,431	$8,959,477	$8,489,772	$7,880,514	$5,253,676	$5,253,676
25000	$32.02	$3,826,300	$4,143,662	$4,487,347	$3,887,630	$4,859,537	$4,859,537
35000	$21.89	$1,569,156	$2,265,741	$2,453,666	$3,985,769	$3,985,769	$3,985,769
40000	$19.84	$1,422,234	$1,540,198	$2,223,927	$2,408,385	$3,010,481	$3,010,481
	Totals	$16,125,121	$16,909,077	$17,654,712	$18,162,297	$17,109,463	$17,109,463

Project Benefits

	1995	2005	2015	2025	2035	2045
Costs without Project	$16,840,163	$17,676,267	$18,570,566	$19,491,614	$19,491,614	$19,491,614
Costs with Project	$16,125,121	$16,909,077	$17,654,712	$18,162,297	$17,109,463	$17,109,463
Savings	$715,042	$767,190	$915,854	$1,329,316	$2,382,151	$2,382,151
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$202,307	$321,161	$183,876	$128,000	$103,361	$52,765
Ave. Annual Benefits	**$991,000**					

Automobiles:

Terminal 7 is used exclusively for receiving automobiles including Acuras, Hondas, and

Isuzus from Japan, and Volkswagens, Audis, Porsches, and Volvos from Europe. In 1988, approximately half of the 132,289 short tons of autos handled at Richmond were from Europe; the other half were from Japan. The autos are brought in by box-shaped car carriers which range from 15,000 to 28,000 DWT and feature design drafts ranging from 22 to 38 feet respectively. Since the operating drafts only range from 22 to 30 feet, no benefits were calculated for automobiles.

Dry Bulk:

Terminals 9, 15, and 3 handle dry bulk. Commodities include scrap metals, petroleum coke, cement, metal ores, gypsum rock, and metal products. In contrast to liquid bulk and automobile vessels which make stops to various harbors, dry bulk vessels sail directly to their destinations.

Scrap Metal: (Terminal 9)

Levin-Richmond exports an average of 250,000 short tons of scrap metal per year to markets in the Far East where the metals are melted down and processed into steel products. The destinations are South Korea, India, Taiwan and Japan. The scrap metal operation uses two bulk cargo vessels; one with a 34-foot draft, the other with a 36-foot draft. The 34-foot draft vessel is used more frequently than the larger vessel. The frequency of trips averages once a month, and the tidal waiting time ranges from 4 to 10 hours. The average time spent in port is approximately one week.

A great potential exists for expansion of this operation. According to a "San Francisco Chronicle" dated Jan. 8, 1990, Levin Metals also operates scrap yards in Redwood City, San Jose, Stockton, Sacramento and is in the process of acquiring a sixth scrap yard in Rancho Cordova. Representatives of shipping companies indicate that larger vessels are highly desirable to continue supporting the scrap metal operation. According to the representatives, 40-foot draft vessels are ideal, but 38-foot draft vessels would still be very beneficial for transporting more scrap metal, and reducing the costs per ton.

Because Levin-Richmond uses two bulk cargo vessels that are not loading to full capacity, both will benefit from the project. A deeper harbor would allow companies to switch to larger vessels with 38 foot drafts and deadweight tonnages of 40,000 DWT. There are two sets of savings; one for the 27,500 DWT vessel, the other for the 35,000 DWT vessel. Table 4a shows how the sea and port costs were calculated for the without and with project condition. Table 4b presents the unit costs for the without and with project condition. Table 4c presents the benefits to the project, which amount to $993,000.

Table 4a-- Scrap Metal
Richmond Inner Harbor Project
Sea/Port Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
27500	33'	9844	14	703	$501	$352,203	336	$411	$138,096
35000	36'	9844	14	703	$548	$385,244	336	$451	$151,536

With Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
40000	38'	9844	14	703	$582	$409,146	336	$479	$160,944
40000	38'	9844	14	703	$582	$409,146	336	$479	$160,944

Table 4b-- Scrap Metal
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
27500	33'	0	0	27500	$12.81	$5.02	$17.83
35000	36'	0	0	35000	$11.01	$4.33	$15.34

With Project Conditions

DWT	Max Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
40000	38'	0	0	40000	$10.23	$4.02	$14.25
40000	38'	0	0	40000	$10.23	$4.02	$14.25

Table 4c-- Scrap Metal
Richmond Inner Harbor Project
Benefit Calculations

Project Benefits

	Unit Cost	1995	2005	2015	2025	2035	2045
Tonnage		199,855	227,410	258,764	294,441	294,441	294,441
Costs w/o Proj.		$3,563,222	$4,054,500	$4,613,513	$5,249,600	$5,249,600	$5,249,600
Costs with Proj.	$17.83	$2,848,380	$3,241,100	$3,687,966	$4,196,443	$4,196,443	$4,196,443
Savings	$14.25	$714,842	$813,400	$925,547	$1,053,157	$1,053,157	$1,053,157
Decadal Factor		0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
		$202,306	$340,506	$185,822	$101,408	$48,635	$23,327
Ave. Annual Benefits		**$902,000**					

Project Benefits

	Unit Cost	1995	2005	2015	2025	2035	2045
Tonnage		66,618	75,803	86,254	98,146	98,146	98,146
Costs w/o Proj.	$15.24	$1,021,690	$1,162,555	$1,322,842	$1,505,729	$1,505,729	$1,505,729
Costs with Proj.	$14.25	$949,455	$1,080,361	$1,229,315	$1,398,807	$1,398,807	$1,398,807
Savings		$72,235	$82,195	$93,527	$106,422	$106,422	$106,422
Decadal Factor		0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
		$20,438	$34,408	$18,777	$10,247	$4,915	$2,357
Ave. Annual		**$91,000**					

Total Average Annual Benefits = $ 902,000 + $ 91,000 = $993,000

<u>Coke</u> (Terminal 9)

The other major export handled at this Terminal is petroleum coke which goes to Vladivostok, Russia. Exporting petroleum coke occurs once a month in vessels that range from 21,650 to 65,000 DWT with design drafts from 32 to 42 feet. Since these vessels often light-load, a deeper channel would permit them to load more fully, thereby reducing the unit costs per ton. Without a project, coke vessels with operating drafts of 38 feet are entering the harbor two feet light loaded. Instead of carrying the maximum DWT of 40,000, vessels are carrying 36,855 tons. Under the 38-foot project condition, vessels could easily carry 40,000 tons, resulting in a savings of $275,000 (Tables 5a-c) in the form of light loading benefits.

Table 5a-- Coke
Richmond Inner Harbor Project
Sea/Port Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
40000	38'	9126	14	652	$582	$379,464	192	$479	$91,968

With Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
40000	38'	9126	14	652	$582	$379,464	192	$479	$91,968

Table 5b--Coke
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Light Load (ft)	Tons Lt Loaded	Actual Tons	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
40000	38'	2	3,145	36,855	$10.29	$2.50	$12.79

With Project Conditions

DWT	Max Des. Draft	Light Load (ft)	Tons Lt Loaded	Actual Tons	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
40000	38'	0	0	40,000	$9.48	$2.30	$11.78

Table 5c-- Coke
Richmond Inner Harbor Project
Benefit Calculations

Project Benefits

	Unit Cost	1995	2005	2015	2025	2035	2045
Tonnage		216,508	246,359	280,326	318,976	318,976	318,976
Costs w/o Proj.	$12.79	$2,768,984	$3,150,757	$3,585,166	$4,079,470	$4,079,470	$4,079,470
Costs with	$11.78	$2,551,275	$2,903,032	$3,303,286	$3,758,726	$3,758,726	$3,758,726
Savings		$217,709	$247,725	$281,880	$320,744	$320,744	$320,744
Decadal Factor		0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
		$61,596	$103,703	$56,593	$30,884	$14,812	$7,104
Ave. Annual Benefits		**$275,000**					

Cement (Terminal 9)

According to a 1993 survey, only two vessels were used for the cement operation. The vessels are approximately 27,500 DWT and have maximum design drafts of 34 feet. The fully-loaded vessels enter Richmond Harbor twice a month from 4 ports in Mexico: Hermosillo, Guaymas, Monterrey and Manzanillo. The three former Mexican ports measure 30 feet deep while the Manzanillo port measures 42 feet deep. In calculating the benefits for cement, only a quarter of the total cement volume will be eligible for economies of scale benefit. The shallow waters in three of the four Mexican ports limit access by the larger vessels.

As seen in Table 6a, vessels with design drafts of 34 feet and 30,000 DWT were examined under existing conditions and larger vessels, with design drafts of 38 feet and 40,000 DWT, were examined under project conditions. The larger vessels reduce the unit costs (Table 6b), resulting in $101,000 in average annual savings (Table 6c).

Table 6a-- Cement
Richmond Inner Harbor Project
Sea/Port Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
27500	34'	3100	14	221	$517	$114,479	72	$425	$30,600

With Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
40000	38'	3100	14	221	$582	$128,871	72	$479	$34,488

Table 6b-- Cement
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
27500	33'	0	0	27500	$3.82	$1.02	$4.84

With Project Conditions

DWT	Max Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
40000	38'	0	0	40000	$3.22	$0.86	$4.08

Table 6c-- Cement
Richmond Inner Harbor Project
Benefit Calculations

Project Benefits

	Unit Cost	1995	2005	2015	2025	2035	2045
onnage		61,609	77,855	151,949	212,278	212,278	212,278
osts w/o Proj.	$4.84	$376,819	$526,428	$735,435	$1,027,423	$1,027,423	$1,027,423
osts with Proj.	$4.08	$317,649	$443,765	$619,953	$866,092	$866,092	$866,092
avings		$59,170	$82,662	$115,481	$161,331	$161,331	$161,331
ecadal Factor		0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
		$16,740	$34,604	$23,185	$15,535	$7,450	$3,573
ve. Annual enefits		**$101,000**					

Bauxite (Terminal 9)

Vessels carrying bauxite from Australia generally arrive once a month. The sizes of these vessels range from 25,000 to 62,000 DWT with design drafts of 31 to 41 feet. The operating drafts range from 23 to 36 feet. Tidal waiting times range from 6 to 10 hours. The deepening project would allow larger vessels to enter and would reduce tidal delays. The hypothetical 35-foot draft bulk vessel with 30,000 DWT can enter the harbor fully-loaded. Under 38-foot project conditions, larger vessels with 40,000 DWT could enter safely. The increased tonnage shipped reduces the unit cost from $21.92/ton to $18.51/ton. This represents an average annualized savings of $669,000. Tables 7a through 7c present the economies of scale benefit derivations for bauxite.

Table 7a-- Bauxite
Richmond Inner Harbor Project
Sea/Port Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
30000	35'	13,940	14	996	$517	$514,784	336	$425	$142,800

With Project Conditions

DWT	Max Des.. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
40000	38'	13,940	38	996	$582	$579,506	336	$479	$160,944

Table 7b-- Bauxite
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Lt. Load (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
30000	0	0	30000	$17.16	$4.76	$21.92

With Project Conditions

DWT	Lt. Load (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
40000	0	0	40000	$14.49	$4.02	$18.51

Table 7c-- Bauxite
Richmond Inner Harbor Project
Benefit Calculations

Project Benefits

	Unit Cost	1995	2005	2015	2025	2035	2045
onnage		114,860	160,463	224,171	313,174	313,174	313,174
osts w/o Proj.	$21.92	$2,517,735	$3,517,348	$4,913,837	$6,864,772	$6,864,772	$6,864,772
osts with Proj.	$18.51	$2,126,062	$2,970,170	$4,149,413	$5,796,849	$5,796,849	$5,796,849
avings		$391,673	$547,179	$764,424	$1,067,923	$1,067,923	$1,067,923
ecadal Factor		0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
		$110,816	$229,060	$153,473	$102,830	$49,317	$23,654
ve. Annual enefits		**$669,000**					

Gypsum Rock (Terminal 15)

Gold Bond Building Products uses one vessel, the Gold Bond Conveyor, in this operation. In 1988, this vessel made eight trips importing gypsum rock from San Macros Island,

Mexico for use in the production of wallboard. The vessel usually operates at a draft of 31.5 feet, enters fully loaded, and waits for tides. The size of the ship is 26,459 DWT with the maximum design draft of 33 feet. The usual shipment, which exceeds 26,000 short tons, indicates the vessel is already running at maximum capacity.

Accounting for the cargos expected annual growth of 3.4%, projected by Manalytics Inc. San Francisco Bay Area Cargo Forecast to 2020, October 5, 1988, the Gold Bond Conveyor would have to make 19 trips in 2015 and 51 trips by the year 2045. Therefore, the company is likely to use a larger ship; as a result, economies of scale benefits are calculated using a 35,000 DWT vessel with maximum design draft of 36 feet. A vessel larger than 35,000 DWT was not chosen because of California's environmental law on air quality standards and the limited storage space at the facility. The Gold Bond vessel enters Richmond Harbor fully-loaded with a maximum draft of 33 feet. However, a larger vessel with a maximum design draft of 36 feet will lower the unit costs. The average annual benefits total $350,000, and are derived in Tables 8a through 8c.

Table 8a-- Gypsum Rock
Richmond Inner Harbor Project
Sea/Port Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
26500	33'	3000	14	214	$494	$105,857	72	$406	$29,232

With Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
35000	36'	3000	14	214	$548	$117,429	72	$451	$32,472

Table 8b-- Gypsum Rock
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Max. Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
26,500	33'	0	0	26500	$3.99	$1.10	$5.10

With Project Conditions

DWT	Max. Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
35,000	36'	0	0	35000	$3.36	$0.92	$4.28

Table 8c-- Gypsum Rock
Richmond Inner Harbor Project
Benefit Calculations

Project Benefits

	Unit Cost	1995	2005	2015	2025	2035	2045
onnage		251,381	351,187	490,618	685,405	685,405	685,405
osts w/o Proj.	$5.10	$1,281,468	$1,790,248	$2,501,028	$3,494,008	$3,494,008	$3,494,008
osts with Proj.	$4.28	$1,074,681	$1,501,361	$2,097,444	$2,930,190	$2,930,190	$2,930,190
avings		$206,787	$288,887	$403,583	$563,818	$563,818	$563,818
ecadal Factor		0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
		$58,506	$120,934	$81,027	$54,290	$26,037	$12,488
ve. Annual enefits		**$353,000**					

Coils and Steel Pipe (Terminal 3)

The Port of Richmond receives steel coils and steel pipe from Korea, Holland and New Zealand. The vessels used by the Port of Richmond sail along the U.S. West Coast and make stops in Long Beach and the Port of San Francisco before entering Richmond Harbor. Investigation of vessel operations indicate that vessel operating drafts range from 21 to 29 feet, which are not constrained by the channel depths to warrant benefit estimation.

Petroleum Products

The companies occupying Terminals 8, 14, and 10 handle fuels, alcohols, solvents and other petroleum products. Time Oil is located in Terminal 8; Atlantic Richfield (ARCO) is in Terminal 14; and Texaco is in Terminal 10.

A) Terminal 8

Time Oil warehouses methanol, asphalt, diesel fuel and jet fuel in its facility. These products arrive either by pipeline, trucks, vessels or barges. Jet fuel is transported by barges from the Gulf of Mexico. Time Oil uses parcel tankers to import methanol from Vancouver, British Columbia, and larger vessels to transport diesel fuel and other petroleum products. In 1988, vessels made 14 trips while barges made 25 trips. The sizes of vessels range from 10,000 to 49,500 DWT with design drafts ranging from 27 to 43 feet. Operating drafts range from 19 to 36 feet. In 1988, vessels transported 115,371 short tons while barges transported 97,010 short tons. (Tonnages from barges were not included in the benefit calculations.) The facility operators indicate that the deepening project would allow clients to bring in larger vessels.

B) Terminal 14

ARCO handles petroleum products such as gasoline and jet fuel. ARCO's petroleum product activity can be summarized as a triangular operation in which Cherry Point in Washington State, Richmond Harbor and Long Beach Harbor form the three points of the triangle. In 1988, 280,000 tons of petroleum products, not including jet fuel, were shipped into Richmond Harbor.

ARCO also handles jet fuel which comes from refineries in the Gulf of Mexico, and is usually transported in fully loaded, 34-foot draft tankers. With the deepening project, the fuel could be carried more efficiently in 37-foot draft tankers. Approximately 112,000 tons of jet fuel are transported annually to Richmond Harbor.

C) Terminal 10

No benefits were calculated for Texaco since the vessels' operating drafts are shallow, ranging from 21 to 30 feet. Based on information provided, it is assumed that a deeper channel would not affect their operations.

Tables 11a-c show how the benefits for petroleum products were calculated. Without the project, vessels with 37-foot drafts and 40,000 DWT enter the harbor one-foot light loaded. With 38-foot project conditions, these same vessels can load to capacity. The resulting average annual savings are $150,000.

The future tonnages for petroleum were adjusted to reflect the changing composition of vessels, namely an increased reliance on larger vessels. In 1988, 9% of petroleum vessels had

DWT of 40,000. By 2045, this percentage is expected to be 20% without project conditions and 25% with project conditions. Therefore, the amount of tonnages eligible for benefit is greater for vessels with project conditions than without project conditions.

Table 9a-- Petroleum Products
Richmond Inner Harbor Project
Sea/Port Cost Derivations

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
25000	32'	1,600	14	114	$1,574	$179,866	24	$1,487	$35,688
35000	35'	1,600	14	114	$1,757	$200,800	24	$1,659	$39,616
40000	37'	1,600	14	114	$1,639	$210,171	24	$1,737	$41,688

Table 9b--Petroleum Products
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Light Load (ft)	Tons Lt Load	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
25000	32'	0	0	25,000	$7.20	$1.43	$8.63
35000	35'	0	0	35,000	$5.74	$1.14	$6.87
40000	37'	1	1,626	38,374	$5.48	$1.09	$6.30

With Project Conditions

DWT	Max Des. Draft	Light Load (ft)	Tons Lt Load	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
25000	32'	0	0	25,000	$7.20	$1.43	$8.63
35000	35'	0	0	35,000	$5.74	$1.14	$6.87
40000	37'	0	0	40,000	$5.25	$1.04	$6.30

Table 9c-- Petroleum Products
Richmond Inner Harbor Project

Without Project Conditions

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,536,264	$1,944,961	$2,423,910	$3,452,344	$3,452,344	$3,452,344
35000	$6.87	$680,447	$1,162,982	$1,656,420	$2,359,218	$2,359,218	$2,359,218
40000	$6.56	$779,548	$1,110,300	$1,844,950	$2,627,739	$2,627,739	$2,627,739
	Totals	$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301

With Project Conditions

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,365,568	$1,701,841	$2,077,638	$2,465,960	$2,465,960	$2,465,960
35000	$6.87	$816,536	$1,162,982	$1,932,490	$2,752,421	$2,752,421	$2,752,421
40000	$6.30	$747,854	$1,242,686	$1,769,942	$2,881,035	$2,881,035	$2,881,035
	Totals	$2,929,959	$4,107,509	$5,780,069	$8,099,416	$8,099,416	$8,099,416

Project Benefits

	1995	2005	2015	2025	2035	2045
Costs without Project	$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301
Costs with Project	$2,929,959	$4,107,509	$5,780,069	$8,099,416	$8,099,416	$8,099,416
Savings	$66,300	$110,734	$145,211	$339,885	$339,885	$339,885
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$18,758	$46,355	$29,154	$32,727	$15,696	$7,528
Ave. Annual Benefits	**$150,000**					

Jet Fuel:

Jet fuel vessels enter Richmond Harbor fully loaded with 30,000 DWT and with 34-foot drafts. Given a 38-foot project, larger vessels with 50,000 DWT and 40-foot drafts can enter Richmond Harbor 1 foot light-loaded. The resulting benefits which are presented in Tables 10a- 10c, amount to $780,000.

Table 10a-- Jet Fuel
Richmond Inner Harbor Project
Sea/Port Cost Derivations

Without Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
30000	34'	3,000	14	214	$1,665	$356,786	24	$1,573	$37,752

With Project Conditions

DWT	Max Des. Draft	Dist.	Speed	Time at Sea (hrs)	Cost/ Hour at Sea	Cost at Sea	Time in Port (hrs)	Cost/ Hour in Port	Cost at Port
50000	40'	3,000	14	214	$2,003	$429,214	24	$1,891	$45,384

Table 10b-- Jet Fuel
Richmond Inner Harbor Project
Unit Cost Derivations

Without Project Conditions

DWT	Max. Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
30000	34'	0	0	30000	$11.89	$1.26	$13.15

With Project Conditions

DWT	Max. Des. Draft	Lt. Loading (feet)	Amount Lt. Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @ Port	Total Unit Cost
50000	40'	1	1855	48145	$8.91	$0.94	$9.86

Table 10c-- Jet Fuel
Richmond Inner Harbor Project
Benefit Calculations

Project Benefits

	Unit Cost	1995	2005	2015	2025	2035	2045
onnage		143,385	204,221	290,870	414,282	414,282	414,282
osts w/o Proj.	$13.15	$1,885,69	$2,685,767	$3,825,304	$5,448,331	$5,448,331	$5,448,331
osts with	$9.86	$1,413,43	$2,013,138	$2,867,287	$4,083,840	$4,083,840	$4,083,840
avings		$472,257	$672,629	$958,017	$1,364,492	$1,364,492	$1,364,492
ecadal Factor		0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
		$125,361	$263,819	$180,203	$123,091	$59,028	$28,313
Ave. Annual enefits		**$780,000**					

Tidal Delay Benefits

Appendix F displays the tidal delay costs under 35-foot conditions and with the 38-foot project. The projected number of vessel trips multiplied by the tidal delay cost per trip equals the total projected costs. The projected annual savings resulting from a reduction in tidal waiting times are approximately $ 132,000.

Capping of Asbestos

Some of the surplus dredge material will be used to cap an contaminated portion of the Point Potrero Marine Terminal. Twenty-four inches of compacted dredge material will be placed over 48 acres of the site, which represents 154,280 cubic yards. The 154,280 cubic yards of available material eliminates the need to purchase material from outside sources. According to the latest District's MCASES reports, the cost of capping material is approximately $11 per cubic yard. Therefore, the savings are ($11/cy) × (154,280 cy) = $1,704,000 or $133,000 in average annual terms. These benefits are identical for all of the alternative projects.

Benefits for 36 and 37-Foot Harbor Channels

All pre-project conditions remain unchanged. The computations for the alternative project conditions follow the appendices used for the 38-foot depth conditions. As seen in the tables, some larger vessels, which were loading fully under 38-foot project conditions, will now have to light load by a foot or two due to a shallower harbor channel. Also, the benefits of reduced tidal delays are smaller with a 36 or 37-foot channel than with a 38-foot channel. The tidal delay benefits for the 36-foot channel are actually negative given our assumptions that larger ships will use the deeper harbor.

Benefits for 39 and 40-Foot Harbor Channels

At greater harbor depths, companies will achieve lower unit costs upon switching to larger vessels. However, for bulk operations and vegetable oils will probably not switch over immediately upon project completion. A more likely date is the year 2015, when increased tonnages make it advantageous for companies to use larger vessels. For the bulk commodities, two sets of unit costs were determined at the 39-foot and 40-foot conditions; one for the 20 years after project completion (1995-2015), the other for the remaining 30 years (2015-2045). For the scrap metal operation, the two vessels used under 38-foot project conditions will be replaced by one larger vessel.

For petroleum and jet fuel imports, which are expected to increase significantly, it is assumed that companies will adopt larger tankers upon a 40-foot project completion. Switching to larger tankers at the onset will allow companies to realize even larger benefits than they would by waiting until 2015. The resulting marginal benefits are greatest for petroleum and jet fuel operations.

According to the 1993 survey, vegetable oil companies did not express a need for larger vessels with a deeper harbor. What they did want was greater flexibility with the ones they use now. The composition of the 38-foot harbor vessels was changed slightly to reflect what the composition might look like under 39 and 40-foot channel depths (Appendix G). With even deeper harbor channels, parcel tankers will be used only slightly more often than with a 38-foot project. The resulting economic benefits for vegetable oils are not significantly different at greater project depths.

Summary of Benefits & Costs

Table 11 provides the economic benefits expected to accrue as a result of a particular project. The average annual benefits vary from $ 3.2 million for the 36-foot project to $5.4 million for 40-foot project. The table also displays the average annualized benefits by commodity. Table 12 presents the economic costs which were taken from the MCACES cost estimates for FY 1995.

Table 11
Richmond Inner Harbor Project
Average Annualized Benefits by Project Alternative

	36 Feet	37 Feet	38 Feet	39 Feet	40 Feet
Cement	$77,000	$100,000	$101,000	$118,000	$167,000
Scrap Metal	$797,000	$993,000	$993,000	$1,016,000	$1,016,000
Bauxite	$527,000	$669,000	$669,000	$787,000	$787,000
Coke	$143,000	$257,000	$275,000	$351,000	$351,000
Gypsum Rock	$350,000	$350,000	$350,000	$350,000	$350,000
Vegetable Oils	$787,000	$906,000	$991,000	$1,007,000	$1,011,000
Jet Fuel	$565,000	$565,000	$780,000	$925,000	$1,020,000
Petroleum	$150,000	$150,000	$150,000	$154,000	$432,000
Subtotal	$3,396,000	$3,990,000	$4,309,000	$4,708,000	$5,134,000
Tidal Delay Benefits	($243,000)	$35,000	$132,000	$197,000	$198,000
Dredge Material	$133,000	$133,000	$133,000	$133,000	$133,000
Total Average Annualized Benefits	**$3,286,000**	**$4,158,000**	**$4,574,000**	**$5,038,000**	**$5,465,000**

Table 12
Richmond Inner Harbor Project
Summary of Project Costs

Project	Total Project Costs	Interest During Construction	Total Investment Cost	Interest & Amortization	Incremental O & M Costs	Total Annual Costs
36 Feet	$24,779,000	$651,000	$25,430,000	$1,989,000	$25,000	**$2,015,000**
37 Feet	$31,779,000	$869,000	$32,640,000	$2,554,000	$34,000	**$2,588,000**
38 Feet	$33,790,000	$1,090,000	$34,852,000	$2,726,000	$42,000	**$2,769,000**
39 Feet	$44,879,000	$1,305,000	$46,184,000	$3,613,000	$50,900	**$3,664,000**
40 Feet	$51,579,000	$1,523,000	$53,100,000	$4,154,000	$59,000	**$4,213,000**

V. OPTIMIZATION

In order to determine the optimum channel depth, the benefits and costs are compared for each project alternative. The project alternative with the maximum net benefits indicates the NED alternative. Table 13 displays the estimated annualized costs and benefits by project alternative. The benefit computations for the other project alternatives appear in the tables following this appendix. While all projects yield positive net benefits (and B/C ratios greater than one), the 38-foot project yields the greatest average annual net benefits ($1,805,000) and is considered the NED alternative.

Table 13
Richmond Inner Harbor Project
Optimization Analysis

Project Alternative	Annual Benefits	Annual Costs	Net Benefits	B/C Ratio
36 Foot	$3,286,000	$2,015,000	$1,271,000	1.63
37 Foot	$4,158,000	$2,588,000	$1,570,000	1.61
38 Foot	$4,574,000	$2,769,000	$1,805,000	1.65
39 Foot	$5,038,000	$3,664,000	$1,374,000	1.38
40 Foot	$5,465,000	$4,213,000	$1,252,000	1.30

Price Level = 1995
Federal Discount Rate = 7⅝ %

Appendix A
Richmond Inner Harbor Project
ESTIMATED FOREIGN FLAG BULK CARRIER COSTS (1995 PRICE LEVELS)

DWT Machinery	15000 Diesel	25000 Diesel	35000 Diesel	40000 Diesel	50000 Diesel	60000 Diesel
Replacement Cost (000)	$12,948	$17,512	$21,366	$23,120	$26,380	$29,382
CRF: 7.75%, 20 yrs.	0.09996	0.09996	0.09996	0.09996	0.09996	0.09996
Annual Capital Cost	$1,294,304	$1,750,567	$2,135,797	$2,311,218	$2,637,107	$2,937,206
Wages, benefits, Subsistence	$559,481	$565,805	$572,128	$575,290	$581,613	$587,936
Stores & Supplies	$190,616	$200,804	$210,991	$216,084	$226,272	$236,459
Maintenance & Repair	$218,347	$235,332	$252,317	$260,810	$277,795	$294,780
Insurance	$188,472	$208,707	$228,942	$239,060	$259,295	$279,530
Other	$95,366	$96,810	$98,254	$98,976	$100,419	$101,863
Administration	$139,854	$142,107	$144,361	$145,487	$147,740	$149,994
Fixed Annual Op Cost	$1,392,137	$1,449,565	$1,506,992	$1,535,706	$1,593,134	$1,650,561
Total Annual Fixed Costs	$2,686,441	$3,200,131	$3,642,789	$3,846,924	$4,230,241	$4,587,768
Total Daily Fixed Costs	$7,676	$9,143	$10,408	$10,991	$12,086	$13,108
Daily Fuel Costs						
At Sea	$2,115	$2,504	$2,754	$2,972	$3,190	$3,393
In Port	$309	$412	$412	$515	$515	$515
Daily Total Costs						
At Sea	$9,791	$11,647	$13,161	$13,963	$15,276	$16,501
In Port	$7,985	$9,555	$10,820	$11,506	$12,601	$13,623
Hourly Total Costs						
At Sea	$408	$485	$548	$582	$637	$688
In Port	$333	$398	$451	$479	$525	$568
Ship Characteristics						
Length (ft)	478	555	612	637	680	717
Beam (ft)	67	79	88	92	99	105
Draft (ft)	27.6	32.4	36	37.5	40.2	42.6
Cubic Capacity (000 ft)	690	1200	1456	1653	2089	2631
Immersion Rate (tonnes/inch)	62.8	86.7	107.5	117.1	135.3	152.2
Horsepower	9000	11000	12000	13000	14000	15000
Speed	14	14	14	14	14	14
Fuel Consumption (tonnes/day)	20.7	24	26.9	28.2	30.7	33
Main (at sea)	1.5	2	2	2.5	2.5	2.5
Auxiliary (at sea)	1.5	2	2	2.5	2.5	2.5

Appendix B
Richmond Inner Harbor Project
ESTIMATED U.S. FLAG TANKER COSTS - DOUBLE HULL (1995 PRICE LEVELS)

DWT Machinery	20000 Diesel	25000 Diesel	35000 Diesel	50000 Diesel	60000 Diesel	70000 Diesel
Replacement Cost (000)	$52,386	$60,162	$74,124	$92,478	$103,550	$113,939
CRF: 7.75%, 20 yrs.	0.09996	0.09996	0.09996	0.09996	0.09996	0.09996
Annual Capital Cost	$5,236,753	$6,014,095	$7,409,790	$9,244,503	$10,351,316	$11,389,881
Wages, Benefits, Subsistence	$3,248,485	$3,248,534	$3,248,631	$3,248,777	$3,248,874	$3,248,971
Stores & Supplies	$323,522	$326,222	$331,622	$339,722	$345,122	$350,523
Maintenance & Repair	$1,624,498	$1,636,209	$1,659,630	$1,694,763	$1,718,184	$1,741,606
Insurance	$216,456	$228,628	$252,971	$289,486	$313,829	$338,172
Other	$315,587	$313,362	$308,912	$302,236	$297,786	$293,336
Administration	$573,010	$575,491	$580,453	$587,895	$592,857	$597,819
Fixed Annual Op Cost	$6,301,558	$6,328,445	$6,382,218	$6,462,879	$6,516,652	$6,570,426
Total Annual Fixed Costs	$11,538,311	$12,342,540	$13,792,009	$15,707,382	$16,867,968	$17,960,307
Total Daily Fixed Costs	$32,967	$35,264	$39,406	$44,878	$48,194	$51,315
Daily Fuel Costs						
At Sea	$2,264	$2,504	$2,754	$3,190	$3,393	$3,585
In Port	$309	$412	$412	$515	$515	$515
Daily Total Costs						
At Sea	$35,231	$37,769	$42,159	$48,068	$51,587	$54,901
In Port	$33,276	$35,676	$39,818	$45,393	$48,709	$51,830
Hourly Total Costs						
At Sea	$1,468	$1,574	$1,757	$2,003	$2,149	$2,288
In Port	$1,386	$1,487	$1,659	$1,891	$2,030	$2,160
Ship Characteristics						
Length (ft)	519	553	610	676	712	744
Beam (ft)	76	82	92	103	109	115
Draft (ft)	29.5	31.6	35.1	39.3	41.6	43.6
Immersion Rate (tonnes/inch)	81.3	92.2	112	138.5	154.6	169.9
Horsepower	10000	12000	13000	14000	15000	16500
Speed	14	14	14	14	14	14
Fuel Consumption (tonnes/day)						
Main (at sea)	22.4	24	26.9	30.7	33	35.2
Auxiliary (at sea)	1.5	2	2	2.5	2.5	2.5
In Port	1.5	2	2	2.5	2.5	2.5

Appendix C
Richmond Inner Harbor Project

Estimated International Flag/Richmond Tanker Costs — 1995

DWT	17,000	25000	35000	40,000
Replacement Cost- 1995	$13,894,175	$15,213,935	$16,683,635	$17,688,485
CRF 7.75% 20 Yrs. (0.09996)	$ 1,388,861	$ 1,520,784	$ 1,667,696	$ 1,768,140
Fixed Annual Capital Costs	$ 1,388,861	$ 1,520,784	$ 1,667,696	$ 1,768,140
Fixed Annual Operating Costs	$2,777,722	$ 3,041,568	$ 3,335,392	$ 3,536,280
Total Annual Fixed Costs (350 days)	$4,603,999	$ 4,836,503	$ 5,095,545	$ 5,217,304
Total Daily Fixed Costs	$ 13,154	$ 13,818	$ 14,559	$ 14,906
Daily Fuel Cost				
At Sea	$ 4,157	$ 5,063	$6,013	$6,436
In Port	$ 456	$ 684	$684	$684
Daily Total Cost				
At Sea	$17,311	$18,881	$20,571	$21,343
In Port	$13,611	$14,503	$15,243	$15,591
Hourly Cost (24 hr. Day)				
At Sea	$722	$786	$858	$889
In Port	$567	$604	$635	$649
Characteristics				
Draft (ft.) Wax	32.2	34.8	37.2	38.2
Immersion Factor (TPI)	73.9	90.1	111.8	122.3
Speed	14.0	14.0	16.0	16.0
Daily Fuel Consumption				
At Sea	34.5	42.0	49.9	53.4
In Port	2.0	3.0	3.0	3.0

Appendix D
Richmond Inner Harbor Project
PARCEL TANKER COSTS DERIVATION:

A separate operating cost table was developed for the parcel tankers, since OCE data did not cover this class of vessels. Parcel tankers consist of double hulled compartmentalized tankers which are used predominantly for the trade between the Far East and the U.S. West Coast. The following briefly describes the procedures for generating the cost tables.

Operating costs were based on information from a report called Deep Draft Vessel Operating Costs Characteristics Study prepared by IPI Development Associates Incorporated in June 1987. This comprehensive report selected a representative sample size of 400 tankers, ranging from 20,000 to 250,000 DWT, and examined the characteristics which are used to determine operating costs. Regressions were performed for 400 vessels from the study. The regression models used to estimate drafts, immersion factors, operating speed, fuel consumption or fuel costs, total annual costs, and new building prices adopt either the linear function of (a) Y=A+BX or logarithm function of (b) LnY=A+BLnX

The model for total annual costs and new building prices was chosen by identifying the model which yields a greater R squared. The R squared measures "goodness of fit" in a regression analysis. Deciding on the appropriate model for draft, immersion factor, operating speed, or fuel consumption requires some other comparison methods such as (1) generating a fitted value column to compare with the column of actual values, or (2) plotting a graph which requires generating the fitted value column.

Values for the cost table were derived from various indices. Composite construction cost index, Japan labor cost index, Japan exchange rate (yen/$) and fuel prices were updated to reflect the current price levels.

PROJECTED COMPOSITION OF TANKERS (1988-2045)

Vegetable Oils

Without Project Conditions
Parcel Tankers

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	50%	45%	40%	35%	30%	30%
25000	20%	25%	25%	25%	25%	25%	25%
35000	10%	15%	15%	20%	25%	25%	25%
40000	9%	10%	15%	15%	15%	20%	20%
	100%	100%	100%	100%	100%	100%	100%

With Project Conditions (38-foot harbor)

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	45%	40%	35%	30%	20%	20%
25000	20%	25%	25%	25%	20%	25%	25%
35000	10%	15%	20%	20%	30%	30%	30%
40000	9%	15%	15%	20%	20%	25%	25%
	100%	100%	100%	100%	100%	100%	100%

Petroleum

Without Project Conditions
Tankers

DWT	1988	1995	2005	2015	2025	2035	2045
25000	48%	45%	40%	35%	35%	30%	30%
35000	24%	25%	30%	30%	30%	35%	30%
40000	28%	30%	30%	35%	35%	35%	40%
	100%	100%	100%	100%	100%	100%	100%

With Project Conditions (38-foot harbor)

DWT	1988	1995	2005	2015	2025	2035	2045
25000	48%	40%	35%	30%	25%	25%	25%
35000	24%	30%	30%	35%	35%	35%	30%
40000	28%	30%	35%	35%	40%	40%	45%
	100%	100%	100%	100%	100%	100%	100%

Appendix F
Richmond Inner Harbor Project
Tidal Delay Calculations

Without Project

	Projected Number of Vessel Trips							Tidal Delay	Tidal Delay	Tidal Delay	Projected Tidal Delay Costs					
	1988	1995	2005	2015	2025	2035	2045	(feet)	(hours)	Cost/Trip	1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	3	11.4	$736	$1,910	$2,668	$3,728	$5,208	$5,208	$5,208
Scrap Metal	7	8	9	10	11	11	11	3	11.4	$736	$5,542	$6,306	$7,175	$8,165	$8,165	$8,165
	2	2	2	3	3	3	3	5	21.5	$4,557	$8,939	$10,171	$11,574	$13,169	$13,169	$13,169
Coke	5	5	6	6	6	6	6	4	15.6	$1,264	$6,700	$6,973	$7,257	$7,552	$7,552	$7,552
Bauxite	3	4	5	7	10	10	10	4	15.6	$1,264	$4,839	$6,761	$9,445	$13,195	$13,195	$13,195
Gypsum	8	9	13	19	26	26	26	4	15.6	$1,264	$11,990	$16,751	$23,402	$32,693	$32,693	$32,693
Veg oils																
17000	16	14	14	13	12	12	12	1	4	$237	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	4	5	5	6	6	6	6	4	15.6	$1,901	$9,087	$9,840	$10,656	$11,540	$11,540	$11,540
35000	1	2	2	3	4	4	4	5	21.5	$6,854	$14,041	$15,205	$21,955	$29,720	$29,720	$29,720
40000	1	1	2	2	2	2	2	5	21.5	$6,854	$8,190	$13,305	$14,408	$15,603	$15,603	$15,603
Jet Fuel	4	5	7	10	14	14	14	3	11.4	$2,483	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
Petroleum																
25000	6	7	9	11	16	16	16	1	4	$534	$3,805	$4,818	$6,004	$8,552	$8,552	$8,552
35000	2	3	5	7	10	10	10	4	15.6	$1,204	$3,405	$5,819	$8,288	$11,805	$11,805	$11,805
40000	2	3	4	7	10	10	10	5	21.5	$15,444	$45,858	$65,315	$108,533	$154,582	$154,582	$154,582

With Project

	Projected Number of Vessel Trips							Tidal Delay	Tidal Delay	Tidal Delay	Projected Tidal Delay Costs					
	1988	1995	2005	2015	2025	2035	2045	(feet)	(hours)	Cost/Trip	1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	4	15.6	$1,264	$3,792	$5,056	$6,320	$8,848	$8,848	$8,848
Scrap Metal	7	5	6	7	8	8	8	4	15.6	$1,264	$6,451	$7,340	$8,352	$9,504	$9,504	$9,504
	2	2	2	2	2	2	2	4	15.6	$1,264	$1,970	$2,241	$2,550	$2,902	$2,902	$2,902
Coke	5	5	5	6	6	6	6	1	4	$158	$803	$836	$870	$906	$906	$906
Bauxite	3	3	4	6	8	8	8	4	15.6	$1,264	$3,630	$5,071	$7,084	$9,896	$9,896	$9,896
Gypsum	8	7	10	14	20	20	20	4	15.6	$1,264	$9,078	$12,683	$17,718	$24,753	$24,753	$24,753
Veg oils																
17000	16	13	12	12	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
25000	4	5	5	6	5	5	5	1	4	$237	$1,133	$1,227	$1,329	$1,151	$1,151	$1,151
35000	1	2	3	3	5	5	5	2	6	$535	$1,096	$1,582	$1,714	$2,784	$2,784	$2,784
40000	1	2	2	3	3	3	3	2	6	$535	$959	$1,039	$1,500	$1,624	$1,624	$1,624
Jet Fuel	4	3	4	6	8	8	8	4	15.6	$4,273	$12,254	$17,453	$24,858	$35,405	$35,405	$35,405
Petroleum																
25000	6	6	8	10	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
35000	2	3	5	8	11	11	11	1	4	$534	$1,812	$2,581	$4,289	$6,108	$6,108	$6,108
40000	2	3	5	7	11	11	11	2	6	$1,204	$3,575	$5,941	$8,461	$13,773	$13,773	$13,773

PROJECTED SAVINGS

	1995	2005	2015	2025	2035	2045
Cement	($1,882)	($2,388)	($2,592)	($3,640)	($3,640)	($3,640)
Scrap Metal	($909)	($1,034)	($1,177)	($1,339)	($1,339)	($1,339)
	$6,969	$7,930	$9,024	$10,268	$10,268	$10,268
Coke	$5,896	$6,136	$6,386	$6,646	$6,646	$6,646
Bauxite	$1,210	$1,690	$2,361	$3,299	$3,299	$3,299
Gypsum	$2,912	$4,068	$5,683	$7,940	$7,940	$7,940
Veg oils	$0	$0	$0	$0	$0	$0
17000	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	$7,954	$8,613	$9,328	$10,389	$10,389	$10,389
35000	$12,945	$13,623	$20,241	$26,936	$26,936	$26,936
40000	$7,231	$12,266	$12,909	$13,979	$13,979	$13,979
Jet Fuel	($8,922)	($14,205)	($21,732)	($32,442)	($32,442)	($32,442)
Petroleum	$0	$0	$0	$0	$0	$0
25000	$3,805	$4,818	$6,004	$8,552	$8,552	$8,552
35000	$1,593	$3,238	$4,000	$5,697	$5,697	$5,697
40000	$42,283	$59,375	$100,072	$140,809	$140,809	$140,809
Total	$84,418	$107,378	$153,633	$200,055	$200,055	$200,055
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$23,884	$44,951	$30,845	$19,263	$9,239	$4,431
Total Tidal Savings		$132,613				

Appendix G
Richmond Inner Harbor Project
Vegetable Oils Composition

With 39-foot project conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	45%	40%	35%	30%	20%	20%
25000	20%	25%	25%	25%	20%	25%	25%
35000	10%	15%	20%	18%	28%	28%	28%
40000	9%	15%	15%	22%	22%	27%	27%
	100%	100%	100%	100%	100%	100%	100%

Projected Tonnages

1988	1995	2005	2015	2025	2035	2045
275,757	215,096	207,055	196,200	182,120	121,413	121,413
90,412	119,498	129,409	140,143	121,413	151,766	151,766
45,206	71,699	103,527	100,903	169,978	169,978	169,978
40,685	71,699	77,646	123,326	133,554	163,908	163,908
452,060	477,991	517,637	560,571	607,066	607,066	607,066

With 40-foot project conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	45%	40%	35%	30%	20%	20%
25000	20%	25%	25%	25%	20%	25%	25%
35000	10%	15%	20%	17%	27%	28%	27%
40000	9%	15%	15%	23%	23%	27%	28%
	100%	100%	100%	100%	100%	100%	100%

Projected Tonnages

1988	1995	2005	2015	2025	2035	2045
275,757	215,096	207,055	196,200	182,120	121,413	121,413
90,412	119,498	129,409	140,143	121,413	151,766	151,766
45,206	71,699	103,527	95,297	163,908	169,978	163,908
40,685	71,699	77,646	128,931	139,625	163,908	169,978
452,060	477,991	517,637	560,571	607,066	607,066	607,066

With 37-foot project conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	45%	40%	35%	30%	25%	23%
25000	20%	26%	26%	25%	20%	25%	24%
35000	10%	17%	21%	23%	28%	26%	27%
40000	9%	12%	13%	17%	22%	24%	26%
	100%	100%	100%	100%	100%	100%	100%

1988	1995	2005	2015	2025	2035	2045
275,757	215,096	207,055	196,200	182,120	151,766	139,625
90,412	124,278	134,586	140,143	121,413	151,766	145,696
45,206	81,258	108,704	128,931	169,978	157,837	163,908
40,685	57,359	67,293	95,297	133,554	145,696	157,837
452,060	477,991	517,637	560,571	607,066	607,066	607,066

With 36-foot project conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	45%	40%	35%	30%	25%	20%
25000	20%	27%	27%	26%	20%	25%	25%
35000	10%	17%	20%	23%	28%	26%	27%
40000	9%	11%	13%	16%	22%	24%	28%
	100%	100%	100%	100%	100%	100%	100%

1988	1995	2005	2015	2025	2035	2045
275,757	215,096	207,055	196,200	182,120	151,766	121,413
90,412	129,058	139,762	145,748	121,413	151,766	151,766
45,206	81,258	103,527	128,931	169,978	157,837	163,908
40,685	52,579	67,293	89,691	133,554	145,696	169,978
452,060	477,991	517,637	560,571	607,066	607,066	607,066

Vegetable Oils
Without Project Conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	50%	45%	40%	35%	35%	35%
25000	20%	25%	25%	25%	25%	25%	25%
35000	10%	15%	15%	20%	25%	25%	25%
40000	9%	10%	15%	15%	15%	15%	15%
	100%	100%	100%	100%	100%	100%	100%

Vegetable Oils
With Project Conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	61%	45%	40%	35%	30%	20%	20%
25000	20%	25%	25%	25%	20%	25%	25%
35000	10%	15%	20%	20%	30%	30%	30%
40000	9%	15%	15%	20%	20%	25%	25%
	100%	100%	100%	100%	100%	100%	100%

Vegetable Oils
Projected Tonnages — Without Project Conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	275,757	238,996	232,937	224,228	212,473	212,473	212,473
25000	90,412	119,498	129,409	140,143	151,766	151,766	151,766
35000	45,206	71,699	77,646	112,114	151,766	151,766	151,766
40000	40,685	47,799	77,646	84,086	91,060	91,060	91,060
	452,060	477,991	517,637	560,571	607,066	607,066	607,066

Vegetable Oils
Projected Tonnages — With Project Conditions

DWT	1988	1995	2005	2015	2025	2035	2045
17000	275,757	215,096	207,055	196,200	182,120	121,413	121,413
25000	90,412	119,498	129,409	140,143	121,413	151,766	151,766
35000	45,206	71,699	103,527	112,114	182,120	182,120	182,120
40000	40,685	71,699	77,646	112,114	121,413	151,766	151,766
	452,060	477,991	517,637	560,571	607,066	607,066	607,066

Appendix H
Richmond Inner Harbor Project

	36 foot harbor	37 foot harbor	38 foot harbor	39 foot harbor	40 foot harbor
Light-Loading	$1,007,000	$1,263,000	$1,367,000	$1,476,000	$1,529,000
Economies of Scale	$2,389,000	$2,727,000	$2,942,000	$3,232,000	$3,605,000
Total	$3,396,000	$3,990,000	$4,309,000	$4,708,000	$5,134,000

BENEFIT CALCULATIONS

36-FOOT PROJECT

Tidal Delay Calculations
36 Foot Project

Without Project	Projected Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045	Tidal Delay (feet)	Tidal Delay (hours)	Tidal Delay Cost	Without Project --- Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	3	11.4	736	$1,910	$2,668	$3,728	$5,208	$5,208	$5,208
Scrap Metal	7	8	9	10	11	11	11	3	11.4	736	$5,542	$6,306	$7,175	$8,165	$8,165	$8,165
Scrap II	2	2	2	3	3	3	3	5	21.5	4557	$8,939	$10,171	$11,574	$13,169	$13,169	$13,169
Coke	5	5	6	6	6	6	6	4	15.6	1264	$6,700	$6,973	$7,257	$7,552	$7,552	$7,552
Bauxite	3	4	5	7	10	10	10	4	15.6	1264	$4,839	$6,761	$9,445	$13,195	$13,195	$13,195
Gypsum	8	9	13	19	26	26	26	4		1264	$11,990	$16,751	$23,402	$32,693	$32,693	$32,693
Veg oils																
17000	16	14	14	13	12	12	12	1	4	237	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	4	5	5	6	6	6	6	4	15.6	1901	$9,087	$9,840	$10,656	$11,540	$11,540	$11,540
35000	1	2	2	3	4	4	4	5	21.5	6854	$14,041	$15,205	$21,955	$29,720	$29,720	$29,720
40000	1	1	2	2	2	2	2	5	21.5	6854	$8,190	$13,305	$14,408	$15,603	$15,603	$15,603
Jet Fuel	4	5	7	10	14	14	14	3	11.4	2483	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
Petroleum																
25000	6	7	9	11	16	16	16	1	4	534	$3,805	$4,818	$6,004	$8,552	$8,552	$8,552
35000	2	3	5	7	10	10	10	4	15.6	4273	$12,084	$20,653	$29,416	$41,896	$41,896	$41,896
40000	2	3	4	7	10	10	10	5	21.5	15444	$45,858	$65,315	$108,533	$154,582	$154,582	$154,582

With Project	Projected Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045				With Project --- Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	4	5	9123	$27,369	$36,492	$45,615	$63,861	$63,861	$63,861
Scrap Metal	7	5	6	7	8	8	8	4	5	9123	$46,561	$52,980	$60,285	$68,596	$68,596	$68,596
Scrap II	2	2	2	2	2	2	2	4	5	9123	$14,215	$16,175	$18,405	$20,943	$20,943	$20,943
Coke	5	5	5	6	6	6	6	1	3	736	$3,743	$3,895	$4,054	$4,219	$4,219	$4,219
Bauxite	3	3	4	6	8	8	8	4	5	9123	$26,197	$36,598	$51,128	$71,427	$71,427	$71,427
Gypsum	8	7	10	14	20	20	20	4	5	9123	$65,524	$91,539	$127,883	$178,657	$178,657	$178,657
Veg oils																
17000	16	13	12	12	11	11	11	0	2	535	$6,769	$6,516	$6,175	$5,731	$5,731	$5,731
25000	4	5	5	6	5	5	5	1	3	1107	$5,291	$5,730	$6,206	$5,376	$5,376	$5,376
35000	1	2	3	3	5	5	5	2	4	4457	$9,130	$13,183	$14,277	$23,192	$23,192	$23,192
40000	1	2	2	3	3	3	3	2	4	4457	$7,989	$8,652	$12,492	$13,528	$13,528	$13,528
Jet Fuel	4	4	5	7	10	10	10	3	5	15444	$55,361	$78,850	$112,305	$159,954	$159,954	$159,954
Petroleum																
25000	6	6	8	10	11	11	11	0	2	1204	$7,627	$9,505	$11,604	$13,773	$13,773	$13,773
35000	2	3	5	8	11	11	11	1	3	2483	$8,426	$12,001	$19,942	$28,403	$28,403	$28,403
40000	2	3	5	7	11	11	11	2	4	4273	$12,688	$21,083	$30,029	$48,879	$48,879	$48,879

PROJECTED SAVINGS

	1995	2005	2015	2025	2035	2045
Cement	($25,459)	($33,824)	($41,887)	($58,653)	($58,653)	($58,653)
Scrap Metal	($41,019)	($46,674)	($53,109)	($60,432)	($60,432)	($60,432)
Scrap II	($5,276)	($6,004)	($6,832)	($7,773)	($7,773)	($7,773)
Coke	$2,957	$3,078	$3,203	$3,333	$3,333	$3,333
Bauxite	($21,357)	($29,837)	($41,683)	($58,232)	($58,232)	($58,232)
Gypsum	($53,534)	($74,788)	($104,482)	($145,964)	($145,964)	($145,964)
Veg oils	$0	$0	$0	$0	$0	$0
17000	($3,437)	($3,269)	($3,049)	($2,769)	($2,769)	($2,769)
25000	$3,795	$4,110	$4,451	$6,164	$6,164	$6,164
35000	$4,910	$2,022	$7,678	$6,529	$6,529	$6,529
40000	$201	$4,653	$1,916	$2,075	$2,075	$2,075
Jet Fuel	($52,029)	($75,602)	($109,179)	($156,992)	($156,992)	($156,992)
Petroleum	$0	$0	$0	$0	$0	$0
25000	($3,821)	($4,687)	($5,600)	($5,221)	($5,221)	($5,221)
35000	$3,658	$8,652	$9,474	$13,493	$13,493	$13,493
40000	$33,170	$44,232	$78,504	$105,703	$105,703	$105,703
Total	($157,241)	($207,939)	($260,594)	($358,740)	($358,740)	($358,740)
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	($44,488)	($87,047)	($52,319)	($34,543)	($16,567)	($7,946)
Total Tidal Savings		($242,911)				

Richmond Inner Harbor Project
36 Foot Project

Cement Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt. Loaded (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30,000	34	Mexico	3,100	14	221	$517	$114,479	72	$425	$30,600	0	0	30,000	$3.82	$1.02	$4.84

With Project Conditions 40 foot project

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt. Loaded (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40,000	38	Mexico	3,100	14	221	$582	$128,871	72	$479	$34,488	1	1626	38,374	$3.36	$0.90	$4.26

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnages		61,609	77,855	108,766	151,949	212,278	212,278	212,278
Without Project	$4.84		$376,504	$525,987	$734,820	$1,026,564	$1,026,564	$1,026,564
With Project	$4.26		$331,435	$463,024	$646,857	$903,678	$903,678	$903,678
Deferred Savings			$45,070	$62,964	$87,962	$122,886	$122,886	$122,886
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$12,752	$26,358	$17,660	$11,833	$5,675	$2,722

Average Annual Savings: $76,999

Richmond Inner Harbor Project
36 Foot Project

Scrap Metal Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt Loading (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
1	27500	34	S. Korea	9844	14	703	$501	$352,203	336	$411	$138,096	0	0	27500	$12.81	$5.02	$17.83
1	35000	36	S. Korea	9844	14	703	$548	$385,244	336	$451	$151,536	0	0	35000	$11.01	$4.33	$15.34

With Project Conditions — 36 foot project

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt Loading (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
2	40000	38	S. Korea	9844	14	703	$582	$409,146	336	$479	$160,944	1	1572.48	38427.52	$10.65	$4.19	$14.84
2	40000	38	S. Korea	9844	14	703	$582	$409,146	336	$479	$160,944	1	1572.48	38427.52	$10.65	$4.19	$14.84

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnages		182,578	199,855	227,410	258,764	294,441	294,441	294,441
w/o project	$17.83	$3,255,193	$3,563,222	$4,054,500	$4,613,513	$5,249,600	$5,249,600	$5,249,600
w/project	$14.84	$2,708,629	$2,964,938	$3,373,728	$3,838,880	$4,368,165	$4,368,165	$4,368,165
Deferred Savings		$546,564	$598,284	$680,772	$774,633	$881,436	$881,436	$881,436
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$169,272	$284,985	$155,523	$84,873	$40,705	$19,524
Average Annual Savings:			$754,882					

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		60,859	66,618	75,803	86,254	98,146	98,146	98,146
w/o project	$15.34	$933,368	$1,021,690	$1,162,555	$1,322,842	$1,505,229	$1,505,229	$1,505,229
w/project	$14.84	$902,871	$988,307	$1,124,570	$1,279,620	$1,456,047	$1,456,047	$1,456,047
Deferred Savings		$30,497	$33,383	$37,986	$43,223	$49,182	$49,182	$49,182
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$9,445	$15,902	$8,678	$4,736	$2,271	$1,089
Average Annual Savings:			$42,121					

Total Average Annual Savings $797,003

Richmond Inner Harbor Project
36 Foot Project

Bauxite Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons ight Loade	ctual Ton Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	30000	35	Australia	13,940	14	996	$517	$514,784	336	$425	$142,800	0	0	30000	$17.16	$4.76	$21.92

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons ight Loade	ctual Ton Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	38	Australia	13,940	14	996	$582	$579,506	336	$479	$160,944	1	1505.28	38494.7	$15.05	$4.18	$19.24

Projected Costs & Savings

	Unit Cost	1993	1995	2005	2015	2025	2035	2045
		90,892	114,860	160,463	224,171	313,174	313,174	313,174
Without Project	$21.92	$1,992,305	$2,517,675	$3,517,264	$4,913,720	$6,864,608	$6,864,608	$6,864,608
With Project	$19.24	$1,748,317	$2,209,347	$3,086,521	$4,311,959	$6,023,931	$6,023,931	$6,023,931
Deferred Savings		$243,988	$308,328	$430,743	$601,761	$840,677	$840,677	$840,677
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$87,235	$180,318	$120,816	$80,949	$38,822	$18,621
Average Annual Savings:			$526,761					

Richmond Inner Harbor Project
36 Foot Project

Coke Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port
	40,000	38	Vlad Russia	9126	14	652	$582	$379,381	192	$479	$91,968

Without Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40,000	38	2	3145	36,855	$10.29	$2.50	$12.79

With Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40,000	38	1	1572	38,428	$9.87	$2.39	$12.27

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnages		197,792	216,508	246,359	280,326	318,976	318,976	318,976
w/o project	$12.79		$2,768,984	$3,150,757	$3,585,166	$4,079,470	$4,079,470	$4,079,470
w/project	$12.27		$2,655,675	$3,021,826	$3,438,459	$3,912,536	$3,912,536	$3,912,536
Deferred Savings			$113,309	$128,931	$146,707	$166,935	$166,935	$166,935
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$32,058	$53,973	$29,454	$16,074	$7,709	$3,698

Average Annual Savings: $142,967

Richmond Inner Harbor Project
36 Foot Project

Gypsum Rock Benefit Calculations

Without Project Condition

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	26500	33	San Marcos I	3000	14	214	$494	$105,857	72	$406	$29,232	0	0	26500	$3.99	$1.10	$5.10

With Project Condition 36 foot project

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	35000	36	San Marcos I	3000	14	214	$548	$117,429	72	$451	$32,472	0	0	35000	$3.36	$0.93	$4.28

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		198,925	251,381	351,187	490,618	685,408	685,408	685,408
w/o project	$5.10	$1,014,061	$1,281,468	$1,790,248	$2,501,028	$3,494,008	$3,494,008	$3,494,008
w/project	$4.28	$851,971	$1,076,635	$1,504,090	$2,101,257	$2,935,517	$2,935,517	$2,935,517
Deferred Savings		$162,090	$204,833	$286,158	$399,771	$558,491	$558,491	$558,491
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$57,953	$119,791	$80,262	$53,777	$25,791	$12,371
Average Annual Savings:			$349,946					

Richmond Inner Harbor Project
36 Foot Project

Vegetable Oils Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port
	17000	32	Far East	14,000	14	1000	$722	$722,000	24	$567	$13,608
	25000	35	Far East	14,000	14	1000	$786	$786,000	24	$604	$14,496
	35000	37	Far East	14,000	16	875	$858	$750,750	24	$635	$15,240
	40000	38	Far East	14,000	16	875	$889	$777,875	24	$649	$15,576

Without Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	32	0	0	17,000	$42.47	$0.80	$43.27
	25000	35	0	0	25,000	$31.44	$0.58	$32.02
	35000	37	1	1505	33,495	$22.41	$0.45	$22.87
	40000	38	2	3279	36,721	$21.18	$0.42	$21.61

With Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	32	0	0	17,000	$42.47	$0.80	$43.27
	25000	35	0	0	25,000	$31.44	$0.58	$32.02
	35000	37	0	0	35,000	$21.45	$0.44	$21.89
	40000	38	1	1640	38,360	$20.28	$0.41	$20.68

Without Project

DWT		Unit Cost	Projected Costs 1995	2005	2015	2025	2035	2045
17000		$43.27	$10,341,590	$10,079,411	$9,702,596	$9,193,708	$9,193,708	$9,193,708
25000		$32.02	$3,826,300	$4,143,662	$4,487,347	$4,859,562	$4,859,562	$4,859,562
35000		$22.87	$1,639,675	$1,775,674	$2,563,936	$3,470,744	$3,470,744	$3,470,744
40000		$21.61	$1,032,832	$1,677,746	$1,816,902	$1,967,600	$1,967,600	$1,967,600
	Cost		$16,840,397	$17,676,493	$18,570,781	$19,491,614	$19,491,614	$19,491,614

With Project

DWT		Unit Cost	Projected Costs 1995	2005	2015	2025	2035	2045
17000		$43.27	$9,307,431	$8,959,477	$8,489,772	$7,880,514	$6,567,095	$5,253,676
25000		$32.02	$4,132,404	$4,475,155	$4,666,840	$3,887,630	$4,859,537	$4,859,537
35000		$21.89	$1,778,377	$2,265,741	$2,821,716	$3,720,051	$3,454,333	$3,587,192
40000		$20.68	$1,087,553	$1,391,895	$1,855,190	$2,762,462	$3,013,595	$3,515,861
	Cost		$16,305,765	$17,092,266	$17,833,518	$18,250,657	$17,894,560	$17,216,266

	Projected Savings 1995	2005	2015	2025	2035	2045
Costs without Project	$16,840,397	$17,676,493	$18,570,781	$19,491,614	$19,491,614	$19,491,614
Costs with Project	$16,305,765	$17,092,266	$17,833,518	$18,250,657	$17,894,560	$17,216,266
Savings	$534,633	$584,226	$737,263	$1,240,957	$1,597,054	$2,275,348
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$151,264	$244,569	$148,020	$119,492	$73,752	$50,399
Ave. Annual Benefits	$787,495					

Richmond Inner Harbor Project
36 Foot Project

Jet Fuel Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30000	34	Gulf of Mexico	3000	14	214	$1,665	$356,786	24	$1,573	$37,752	30000	$11.89	$1.26	$13.15

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40000	37	Gulf of Mexico	3000	14	214	$1,839	$394,071	24	$1,775	$42,600	40000	$9.85	$1.07	$10.92

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		111,940	143,385	204,221	290,870	414,282	414,282	414,282
w/o project	$13.15	$1,472,152	$1,885,692	$2,685,767	$3,825,304	$5,448,331	$5,448,331	$5,448,331
w/project	$10.92	$1,222,025	$1,565,303	$2,229,441	$3,175,364	$4,522,630	$4,522,630	$4,522,630
Deferred Savings		$250,127	$320,390	$456,327	$649,940	$925,702	$925,702	$925,702
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$90,648	$191,028	$130,489	$89,136	$42,749	$20,504
Average Annual Savings:			$564,553					

Richmond Inner Harbor Project
36 Foot Project

Petroleum Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port
	25000	32	Cherry Pt.	1600	14	114	$1,574	$179,886	24	$1,487	$35,688
	35000	35	Cherry Pt.	1600	14	114	$1,757	$200,800	24	$1,659	$39,816
	40000	37	Cherry Pt.	1600	14	114	$1,839	$210,171	24	$1,737	$41,688

Without Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	25000	32	0	0	25000	$7.20	$1.43	$8.62
	35000	35	0	0	35000	$5.74	$1.14	$6.87
	40000	37	1	1626	38374	$5.48	$1.09	$6.56

With Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	25000	32	0	0	25000	$7.20	$1.43	$8.62
	35000	35	0	0	35000	$5.74	$1.14	$6.87
	40000	37	0	0	40000	$5.25	$1.04	$6.30

Without Project Conditions

		Projected Costs					
DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,536,264	$1,944,961	$2,423,910	$3,452,344	$3,452,344	$3,452,344
35000	$6.87	$680,447	$1,162,982	$1,656,420	$2,359,218	$2,359,218	$2,359,218
40000	$6.56	$779,548	$1,110,300	$1,844,950	$2,627,739	$2,627,739	$2,627,739
Total Costs		$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301

With Project Conditions

		Projected Costs					
DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,365,568	$1,701,841	$2,077,638	$2,465,960	$2,465,960	$2,465,960
35000	$6.87	$816,536	$1,162,982	$1,932,490	$2,752,421	$2,752,421	$2,752,421
40000	$6.30	$747,854	$1,242,686	$1,769,942	$2,881,035	$2,881,035	$2,881,035
Costs		$2,929,959	$4,107,509	$5,780,069	$8,099,416	$8,099,416	$8,099,416

	Projected Costs & Savings					
	1995	2005	2015	2025	2035	2045
Costs w/o Project	$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301
Costs with Project	$2,929,959	$4,107,509	$5,780,069	$8,099,416	$8,099,416	$8,099,416
Savings	$66,300	$110,734	$145,211	$339,885	$339,885	$339,885
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$18,758	$46,355	$29,154	$32,728	$15,696	$7,528

Average Annual Savings $150,220

BENEFIT CALCULATIONS

37-FOOT PROJECT

Tidal Delay Calculations
37 Foot Project

Without Project

	Projected Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045	Tidal Delay (feet)	Tidal Delay (hours)	Tidal Delay Cost	Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	3	11.4	$736	$1,910	$2,668	$3,728	$5,208	$5,208	$5,208
Scrap Metal	7	8	9	10	11	11	11	3	11.4	$736	$5,542	$6,306	$7,175	$8,165	$8,165	$8,165
Scrap II	2	2	2	3	3	3	3	5	21.5	$4,557	$8,939	$10,171	$11,574	$13,169	$13,169	$13,169
Coke	5	5	6	6	6	6	6	4	15.6	$1,264	$6,700	$6,973	$7,257	$7,552	$7,552	$7,552
Bauxite	3	4	5	7	10	10	10	4	15.6	$1,264	$4,839	$6,761	$9,445	$13,195	$13,195	$13,195
Gypsum	8	9	13	19	26	26	26	4	15.6	$1,264	$11,990	$16,751	$23,402	$32,693	$32,693	$32,693
Veg oils																
17000	16	14	14	13	12	12	12	1	4	$237	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	4	5	5	6	6	6	6	4	15.6	$1,901	$9,087	$9,840	$10,656	$11,540	$11,540	$11,540
35000	1	2	2	3	4	4	4	5	21.5	$6,854	$14,041	$15,205	$21,955	$29,720	$29,720	$29,720
40000	1	1	2	2	2	2	2	5	21.5	$13,722	$16,397	$26,636	$28,846	$31,238	$31,238	$31,238
Jet Fuel	4	5	7	10	14	14	14	3	11.4	$2,483	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
Petroleum																
25000	6	7	9	11	16	16	16	1	4	$534	$3,805	$4,818	$6,004	$8,552	$8,552	$8,552
35000	2	3	5	7	10	10	10	4	15.6	$4,273	$12,084	$20,653	$29,416	$41,896	$41,896	$41,896
40000	2	3	4	7	10	10	10	5	21.5	$15,444	$45,858	$65,315	$108,533	$154,582	$154,582	$154,582

With Project

	Projected Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045	Tidal Delay (feet)	Tidal Delay (hours)	Tidal Delay Cost	Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	5	21.5	$4,557	$13,671	$18,228	$22,785	$31,899	$31,899	$31,899
Scrap Metal	7	5	6	7	8	8	8	5	21.5	$4,557	$23,257	$26,464	$30,113	$34,264	$34,264	$34,264
Scrap II	2	2	2	2	2	2	2	5	21.5	$4,557	$7,101	$8,080	$9,194	$10,461	$10,461	$10,461
Coke	5	5	5	6	6	6	6	2	6	$356	$1,810	$1,884	$1,961	$2,041	$2,041	$2,041
Bauxite	3	3	4	6	8	8	8	5	21.5	$4,557	$13,085	$18,281	$25,539	$35,678	$35,678	$35,678
Gypsum	8	7	10	14	20	20	20	5	21.5	$4,557	$32,730	$45,725	$63,879	$89,240	$89,240	$89,240
Veg oils																
17000	16	13	12	12	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
25000	4	5	5	6	5	5	5	2	6	$535	$2,557	$2,769	$2,999	$2,598	$2,598	$2,598
35000	1	2	3	3	5	5	5	3	11.4	$1,107	$2,268	$3,274	$3,546	$5,760	$5,760	$5,760
40000	1	2	2	3	3	3	3	3	11.4	$1,107	$1,984	$2,149	$3,103	$3,360	$3,360	$3,360
Jet Fuel	4	4	5	7	10	10	10	4	15.6	$4,273	$15,317	$21,816	$31,072	$44,256	$44,256	$44,256
Petroleum																
25000	6	6	8	10	11	11	11	1	4	$534	$3,383	$4,216	$5,147	$6,108	$6,108	$6,108
35000	2	3	5	8	11	11	11	2	6	$1,204	$4,086	$5,819	$9,670	$13,773	$13,773	$13,773
40000	2	3	5	7	11	11	11	3	11.4	$2,483	$7,373	$12,251	$17,449	$28,403	$28,403	$28,403

PROJECTED SAVINGS

	1995	2005	2015	2025	2035	2045
Cement	($11,761)	($15,560)	($19,057)	($26,691)	($26,691)	($26,691)
Scrap Metal	($17,715)	($20,158)	($22,937)	($26,100)	($26,100)	($26,100)
Scrap II	$1,838	$2,092	$2,380	$2,708	$2,708	$2,708
Coke	$4,889	$5,089	$5,296	$5,512	$5,512	$5,512
Bauxite	($8,246)	($11,520)	($16,094)	($22,483)	($22,483)	($22,483)
Gypsum	($20,739)	($28,974)	($40,477)	($56,547)	($56,547)	($56,547)
Veg oils	$0	$0	$0	$0	$0	$0
17000	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	$6,529	$7,071	$7,657	$8,942	$8,942	$8,942
35000	$11,773	$11,931	$18,409	$23,960	$23,960	$23,960
40000	$14,413	$24,487	$25,743	$27,878	$27,878	$27,878
Jet Fuel	($11,985)	($18,569)	($27,946)	($41,294)	($41,294)	($41,294)
Petroleum	$0	$0	$0	$0	$0	$0
25000	$423	$602	$858	$2,443	$2,443	$2,443
35000	$7,998	$14,834	$19,746	$28,124	$28,124	$28,124
40000	$38,486	$53,064	$91,083	$126,179	$126,179	$126,179
Total	$19,234	$27,637	$47,787	$55,593	$55,593	$55,593
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$5,442	$11,570	$9,594	$5,353	$2,567	$1,231
Total Tidal Savings		$35,757				

Richmond Inner Harbor Project
37 Foot Harbor

Cement Benefit Calculaitons

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time In Port (hrs)	Cost/hr Port	Cost at Port	Lt. Loaded (feet)	Amount Lt Loaded	ctual ton carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30,000	34	Mexico	3,100	14	221	$517	$114,479	72	$425	$30,600	0	0	30,000	$3.82	$1.02	$4.84

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time In Port (hrs)	Cost/hr Port	Cost at Port	Lt. Loaded (feet)	Amount Lt Loaded	ctual ton carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40,000	38	Mexico	3,100	14	221	$582	$128,871	72	$479	$34,488	0	0	40,000	$3.22	$0.86	$4.08

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnages		61,609	77,855	108,766	151,949	212,278	212,278	212,278
Without Project	$4.84		$376,504	$525,987	$734,820	$1,026,564	$1,026,564	$1,026,564
With Project	$4.08		$317,960	$444,199	$620,559	$866,939	$866,939	$866,939
Deferred Savings			$58,545	$81,788	$114,261	$159,626	$159,626	$159,626
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$16,564	$34,238	$22,940	$15,370	$7,372	$3,536
	Average Annual Savings:		$100,020					

Richmond Inner Harbor Project
37 Foot Harbor

Scrap Metal Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt Loading (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
1	27500	34	S. Korea	9844	14	703	$501	$352,203	336	$411	$138,096	0	0	27500	$12.81	$5.02	$17.83
1	35000	36	S. Korea	9844	14	703	$548	$385,244	336	$451	$151,536	0	0	35000	$11.01	$4.33	$15.34

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt Loading (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
2	40000	38	S. Korea	9844	14	703	$582	$409,146	336	$479	$160,944	0	0	40000	$10.23	$4.02	$14.25
2	40000	38	S. Korea	9844	14	703	$582	$409,146	336	$479	$160,944	0	0	40000	$10.23	$4.02	$14.25

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnages		182,578	199,855	227,410	258,764	294,441	294,441	294,441
w/o project	$17.83	$3,255,193	$3,563,222	$4,054,500	$4,613,513	$5,249,600	$5,249,600	$5,249,600
w/project	$14.25	$2,602,147	$2,848,380	$3,241,100	$3,687,966	$4,196,443	$4,196,443	$4,196,443
Deferred Savings		$653,046	$714,842	$813,400	$925,547	$1,053,157	$1,053,157	$1,053,157
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$202,250	$340,506	$185,822	$101,408	$48,635	$23,327
Average Annual Savings:			$901,949					

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		60,859	66,618	75,803	86,254	98,146	111,678	127,076
w/o project	$15.34	$933,368	$1,021,690	$1,162,555	$1,322,842	$1,505,229	$1,712,762	$1,948,909
w/project	$14.25	$867,378	$949,455	$1,080,361	$1,229,315	$1,398,807	$1,591,667	$1,811,118
Deferred Savings		$65,991	$72,235	$82,195	$93,527	$106,422	$121,095	$137,791
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$20,438	$34,408	$18,777	$10,247	$5,592	$3,052
Average Annual Savings:			$92,515					

Total Average Annual Savings $994,463

Richmond Inner Harbor Project
37 Foot Harbor

Bauxite Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons ight Loade	ctual Ton Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	30000	35	Australia	13,940	14	996	$517	$514,784	336	$425	$142,800	0	0	30000	$17.16	$4.76	$21.92

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons ight Loade	ctual Ton Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	38	Australia	13,940	14	996	$582	$579,506	336	$479	$160,944	0	0	40000	$14.49	$4.02	$18.51

Projected Costs & Savings

	Unit Cost	1993	1995	2005	2015	2025	2035	2045
		90,892	114,860	160,463	224,171	313,174	313,174	313,174
Without Project	$21.92	$1,992,305	$2,517,675	$3,517,264	$4,913,720	$6,864,608	$6,864,608	$6,864,608
With Project	$18.51	$1,682,524	$2,126,204	$2,970,369	$4,149,691	$5,797,239	$5,797,239	$5,797,239
Deferred Savings		$309,781	$391,470	$546,895	$764,028	$1,067,370	$1,067,370	$1,067,370
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$110,759	$228,941	$153,394	$102,777	$49,291	$23,642
Average Annual Savings:			$668,804					

Tidal Delays Without Project Conditions	1988	1995	2005	2015	2025	2035	2045
Total Vessel Trips 4 ft tidal delays	3	4	5	7	10	10	10

Richmond Inner Harbor Project
37 Foot Harbor

Coke Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port
	40,000	38	Vlad Russia	9126	14	652	$582	$379,381	192	$479	$91,968

Without Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40,000	38	2	3145	36,855	$10.29	$2.50	$12.79

With Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40,000	38	0	0	40,000	$9.48	$2.30	$11.78

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnages		197,792	216,508	246,359	280,326	318,976	318,976	318,976
w/o project	$12.79		$2,768,984	$3,150,757	$3,585,166	$4,079,470	$4,079,470	$4,079,470
w/project	$11.78		$2,551,275	$2,903,032	$3,303,286	$3,758,726	$3,758,726	$3,758,726
Deferred Savings			$217,709	$247,725	$281,880	$320,744	$320,744	$320,744
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$61,596	$103,703	$56,593	$30,884	$14,812	$7,104

Average Annual Savings: $274,693

Richmond Inner Harbor Project
37 Foot Harbor

Gypsum Rock Benefit Calculations

Without Project Condition

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	ctual Ton Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	26500	33	San Marcos I	3000	14	214	$494	$105,857	72	$406	$29,232	0	0	26500	$3.99	$1.10	$5.10

With Project Condition

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	ctual Ton Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	35000	36	San Marcos I	3000	14	214	$548	$117,429	72	$451	$32,472	0	0	35000	$3.36	$0.93	$4.28

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		198,925	251,381	351,187	490,618	685,408	685,408	685,408
w/o project	$5.10	$1,014,061	$1,281,468	$1,790,248	$2,501,028	$3,494,008	$3,494,008	$3,494,008
w/project	$4.28	$851,971	$1,076,635	$1,504,090	$2,101,257	$2,935,517	$2,935,517	$2,935,517
Deferred Savings		$162,090	$204,833	$286,158	$399,771	$558,491	$558,491	$558,491
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$57,953	$119,791	$80,262	$53,777	$25,791	$12,371
Average Annual Savings:			$349,946					

Richmond Inner Harbor Project
37 Foot Project

Vegetable Oil Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port
	17000	32	Far East	14,000	14	1000	$722	$722,000	24	$567	$13,608
	25000	35	Far East	14,000	14	1000	$786	$786,000	24	$604	$14,496
	35000	37	Far East	14,000	16	875	$858	$750,750	24	$635	$15,240
	40000	38	Far East	14,000	16	875	$889	$777,875	24	$649	$15,576

Without Project Conditions

Vessel	DWT	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	0	0	17,000	$42.47	$0.80	$43.27
	25000	0	0	25,000	$31.44	$0.58	$32.02
	35000	1	1505	33,495	$22.41	$0.45	$22.87
	40000	2	3279	36,721	$21.18	$0.42	$21.61

With Project Conditions

Vessel	DWT	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	0	0	17,000	$42.47	$0.80	$43.27
	25000	0	0	25,000	$31.44	$0.58	$32.02
	35000	0	0	35,000	$21.45	$0.44	$21.89
	40000	0	0	40,000	$19.45	$0.39	$19.84

Projected Costs

Without Project Conditions

Vessel	DWT	Unit Cost	1995	2005	2015	2025	2035	2045
	17000	$43.27	$10,341,590	$10,079,411	$9,702,596	$9,193,933	$9,193,933	$9,193,933
	25000	$32.02	$3,826,300	$4,143,662	$4,487,347	$4,859,537	$4,859,537	$4,859,537
	35000	$22.87	$1,639,675	$1,775,674	$2,563,936	$3,470,744	$3,470,744	$3,470,744
	40000	$21.61	$1,032,832	$1,677,746	$1,816,902	$1,967,600	$1,967,600	$1,967,600
	Cost		$16,840,397	$17,676,493	$18,570,781	$19,491,814	$19,491,814	$19,491,814

Projected Costs

With Project Conditions

Vessel	DWT	Unit Cost	1995	2005	2015	2025	2035	2045
	17000	$43.27	$9,307,431	$8,959,477	$8,489,772	$7,880,514	$5,689,428	$5,253,676
	25000	$32.02	$3,826,300	$4,143,662	$4,487,347	$3,887,630	$5,262,599	$4,859,537
	35000	$21.89	$1,569,156	$2,265,741	$2,453,666	$3,985,769	$4,316,357	$4,674,366
	40000	$19.84	$1,422,234	$1,540,198	$2,223,927	$2,408,385	$3,260,177	$3,530,584
	Cost		$16,125,121	$16,909,078	$17,654,712	$18,162,298	$18,528,561	$18,318,163

Projected Savings

	1995	2005	2015	2025	2035	2045
Costs without Project	$16,840,397	$17,676,493	$18,570,781	$19,491,814	$19,491,814	$19,491,814
Costs with Project	$16,125,121	$16,909,078	$17,654,712	$18,162,298	$18,528,561	$18,318,163
Savings	$715,276	$767,415	$916,069	$1,329,516	$963,253	$1,173,651
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$202,373	$321,255	$183,919	$128,019	$44,483	$25,996

Ave. Ann. Benefits $906,046

Richmond Inner Harbor Project
37 Foot Project

Jet Fuel Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30000	34	Gulf of Mexico	3000	14	214	$1,665	$356,786	24	$1,573	$37,752	0	0	30000	$11.89	$1.26	$13.15

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40000	38	Gulf of Mexico	3000	14	214	$1,839	$394,071	24	$1,775	$42,600	0	0	40000	$9.85	$1.07	$10.92

Projected Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		111,940	143,385	204,221	290,870	414,282	414,282	414,282
w/o project	$13.15	$1,472,152	$1,885,692	$2,685,767	$3,825,304	$5,448,331	$5,448,331	$5,448,331
w/project	$10.92	$1,222,025	$1,565,303	$2,229,441	$3,175,364	$4,522,630	$4,522,630	$4,522,630
Deferred Savings		$250,127	$320,390	$456,327	$649,940	$925,702	$925,702	$925,702
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$90,648	$191,028	$130,489	$89,136	$42,749	$20,504
Average Annual Savings:			$564,553					

Richmond Inner Harbor Project
37 Foot Project

Petroleum Product Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	25000	32	Cherry Pt.	1600	14	114	$1,574	$179,886	24	$1,487	$35,688	0	0	25000	$7.20	$1.43	$8.62
	35000	35	Cherry Pt.	1600	14	114	$1,757	$200,800	24	$1,659	$39,816	0	0	35000	$5.74	$1.14	$6.87
	40000	37	Cherry Pt.	1600	14	114	$1,839	$210,171	24	$1,737	$41,688	1	1626	38374	$5.48	$1.09	$6.56

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40000	37	Cherry Pt.	1600	14	114	$1,839	$210,171	24	$1,737	$41,688	0	0	40000	$5.25	$1.04	$6.30

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40000	37	Cherry Pt.	1600	14	114	$1,839	$210,171	24	$1,737	$41,688	0	0	40000	$5.25	$1.04	$6.30

Without Project Condition

DWT	Unit Cost	1995	2005	Projected Costs 2015	2025	2035	2045
25000	$8.62	$1,536,264	$1,944,961	$2,423,910	$3,452,344	$3,452,344	$3,452,344
35000	$6.87	$680,447	$1,162,982	$1,656,420	$2,359,218	$2,359,218	$2,359,218
40000	$6.56	$779,548	$1,110,300	$1,844,950	$2,627,739	$2,627,739	$2,627,739
Total Costs		$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301

With Project Conditions

DWT	Unit Cost	1995	2005	Projected Costs 2015	2025	2035	2045
25000	$8.62	$1,365,568	$1,701,841	$2,077,638	$2,465,960	$2,465,960	$2,465,960
35000	$6.87	$816,536	$1,162,982	$1,932,490	$2,752,421	$2,752,421	$2,752,421
40000	$6.30	$747,854	$1,242,686	$1,769,942	$2,881,035	$2,881,035	$2,881,035
Costs		$2,929,959	$4,107,509	$5,780,069	$8,099,416	$8,099,416	$8,099,416

	1995	2005	Projected Costs & Savings 2015	2025	2035	2045
Costs w/o Project	$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301
Costs with Project	$2,929,959	$4,107,509	$5,780,069	$8,099,416	$8,099,416	$8,099,416
Savings	$66,300	$110,734	$145,211	$339,885	$339,885	$339,885
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$18,758	$46,355	$29,154	$32,728	$15,696	$7,528

Average Annual Savings $150,220

BENEFIT CALCULATIONS

39-FOOT PROJECT

Tidal Delay Calculations
39 Foot Project

Tidal Delay Calculations

Without Project	Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045	Tidal Delay (feet)	Tidal Delay (hours)	Tidal Delay Cost	Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	3	11.4	$736	$1,910	$2,668	$3,728	$5,208	$5,208	$5,208
Scrap Metal	7	8	9	10	11	11	11	3	11.4	$736	$5,542	$6,306	$7,175	$8,165	$8,165	$8,165
Scrap II	2	2	2	3	3	3	3	5	21.5	$4,557	$8,939	$10,171	$11,574	$13,169	$13,169	$13,169
Coke	5	5	6	6	6	6	6	4	15.6	$1,264	$6,700	$6,973	$7,257	$7,552	$7,552	$7,552
Bauxite	3	4	5	7	10	10	10	4	15.6	$1,264	$4,839	$6,761	$9,445	$13,195	$13,195	$13,195
Gypsum	8	9	13	19	26	26	26	4	15.6	$1,264	$11,990	$16,751	$23,402	$32,693	$32,693	$32,693
Veg oils																
17000	16	14	14	13	12	12	12	1	4	$237	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	4	5	5	6	6	6	6	4	15.6	$1,901	$9,087	$9,840	$10,656	$11,540	$11,540	$11,540
35000	1	2	2	3	4	4	4	5	21.5	$6,854	$14,041	$15,205	$21,955	$29,720	$29,720	$29,720
40000	1	1	2	2	2	2	2	5	21.5	$6,854	$8,190	$13,305	$14,408	$15,603	[illegible]	$15,603
Jet Fuel	4	5	7	10	14	14	14	3	11.4	$2,483	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
Petroleum																
25000	6	7	9	11	16	16	16	1	4	$534	$3,805	$4,818	$6,004	$8,552	$8,552	$8,552
35000	2	3	5	7	10	10	10	4	15.6	$4,273	$12,084	$20,653	$29,416	$41,896	$41,896	$41,896
40000	2	3	4	7	10	10	10	5	21.5	$15,444	$45,858	$65,315	$108,533	$154,582	$154,582	$154,582

With Project	Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045				Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	2	2	3	4	4	4	3	11.4	$736	$1,146	$1,601	$2,237	$3,125	$3,125	$3,125
Scrap Metal	7	4	5	5	6	6	6	3	11.4	$736	$2,942	$3,347	$3,809	$4,334	$4,334	$4,334
Scrap II	2	1	2	2	2	2	2	3	11.4	$736	$981	$1,116	$1,270	$1,445	$1,445	$1,445
Coke	5	4	5	6	6	6	6	0	0	$0	$0	$0	$0	$0	$0	$0
Bauxite	3	2	3	4	6	6	6	3	11.4	$736	$1,691	$2,362	$3,300	$4,610	$4,610	$4,610
Gypsum	8	7	10	14	20	20	20	3	11.4	$736	$5,286	$7,385	$10,317	$14,413	$14,413	$14,413
Veg oils																
17000	16	13	11	10	7	7	7	0	0	$0	$0	$0	$0	$0	$0	$0
25000	4	5	5	4	6	6	6	0	0	$0	$0	$0	$0	$0	$0	$0
35000	1	2	3	5	5	5	5	1	4	$232	$475	$686	$1,115	$1,207	$1,207	$1,207
40000	1	2	3	3	4	4	4	1	4	$232	$416	$600	$650	$880	$880	$880
Jet Fuel	4	3	4	5	7	7	7	2	6	$1,204	$3,090	$4,402	$6,269	$8,929	$8,929	$8,929
Petroleum																
25000	6	6	8	10	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
35000	2	3	5	8	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
40000	2	3	5	7	11	11	11	1	4	$534	$1,586	$2,635	$3,753	$6,108	$6,108	$6,108

PROJECTED SAVINGS

	1995	2005	2015	2025	2035	2045
Cement	$764	$1,067	$1,491	$2,083	$2,083	$2,083
Scrap Metal	$2,600	$2,958	$3,366	$3,831	$3,831	$3,831
Scrap II	$7,958	$9,056	$10,304	$11,725	$11,725	$11,725
Coke	$6,700	$6,973	$7,257	$7,552	$7,552	$7,552
Bauxite	$3,149	$4,399	$6,145	$8,585	$8,585	$8,585
Gypsum	$6,704	$9,366	$13,085	$18,280	$18,280	$18,280
Veg oils	$0	$0	$0	$0	$0	$0
17000	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	$9,087	$9,840	$10,656	$11,540	$11,540	$11,540
35000	$13,565	$14,519	$20,840	$28,513	$28,513	$28,513
40000	$7,775	$12,704	$13,758	$14,723	$14,723	$14,723
Jet Fuel	$241	($1,154)	($3,143)	($5,967)	($5,967)	($5,967)
Petroleum	$0	$0	$0	$0	$0	$0
25000	$3,805	$4,818	$6,004	$8,552	$8,552	$8,552
35000	$12,084	$20,653	$29,416	$41,896	$41,896	$41,896
40000	$44,273	$62,681	$104,780	$148,473	$148,473	$148,473
Total	$122,037	$161,127	$227,085	$302,748	$302,748	$302,748
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$34,528	$67,451	$45,592	$29,152	$13,981	$6,706
Total Tidal Savings		$197,409				

Richmond Inner Harbor Porject
39 Foot Project

Cement Benefits Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt. Loaded (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30,000	34	Mexico	3,100	14	221	$517	$114,479	72	$425	$30,600	0	0	30,000	$3.82	$1.02	$4.84

With Project Conditions — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt. Loaded (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	40,000	38	Mexico	3,100	14	221	$582	$128,871	72	$479	$34,488	0	0	40,000	$3.22	$0.86	$4.08

With Project Conditions — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt. Loaded (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	50,000	40	Mexico	3,100	14	221	$637	$141,050	72	$525	$37,800	0	0	50,000	$2.82	$0.76	$3.58

Projected Costs & Savin (1995-2015)

	Unit Cost	1988	1995	2005	2015
Tonnages		61,609	77,855	108,766	151,949
Without Proj	$4.84		$376,504	$525,987	$734,820
With Project	$4.08		$317,960	$444,199	$620,559
Deferred Savings			$58,545	$81,788	$114,261
Decadal Factor			0.28293	0.41862	0.20077
			$16,564	$34,238	$22,940
Average Annual Savings			$73,742		

Projected Costs & Savin (2015-2045)

	Unit Cost	2015	2025	2035	2045
Tonnages		151,949	212,278	212,278	212,278
Without Proj	$4.84		$1,026,566	$1,026,566	$1,026,566
With Project	$3.58		$759,318	$759,318	$759,318
Deferred Savings			$267,248	$267,248	$267,248
Decadal Factor			0.09629	0.04618	0.02215
			$25,733	$12,342	$5,920
Average Annual Savings			$43,094		

Total Average Annual Savings: $117,737

Richmond Inner Harbor Project
39 Foot Project

Scrap Metal Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt Loading (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
27500	34	S. Korea	9844	14	703	$501	$352,203	336	$411	$138,096	0	0	27500	$12.81	$5.02	$17.83
35000	36	S. Korea	9844	14	703	$548	$385,244	336	$451	$151,536	0	0	35000	$11.01	$4.33	$15.34

With Project Conditions (1995-2015) — 39 foot harbor

Vessel DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt Loading (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
40000	38	S. Korea	9844	14	703	$582	$409,146	336	$479	$160,944	0	0	40000	$10.23	$4.02	$14.25

With Project Conditions (2015-2045) — 39 foot harbor

Vessel DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Lt Loading (feet)	Amount Lt Loaded	Actual tons carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
50000	40	S. Korea	9844	14	703	$637	$447,811	336	$525	$176,400	0	0	50000	$8.96	$3.53	$12.40

Projected Costs & Savings (1995-2015)

	Unit Cost	1988	1995	2005	2015
Tonnages		182,578	199,855	227,410	258,764
w/o project	$17.21	$3,142,167	$3,439,501	$3,913,721	$4,453,324
w/project	$14.25	$2,601,737	$2,847,931	$3,240,588	$3,687,384
Deferred Savings			$591,570	$673,133	$765,941
Decadal Factor			0.28293	0.41862	0.20077
			$167,373	$281,787	$153,778

Projected Costs & Savings (2015-2045)

	Unit Cost	2025	2035	2045
Tonnages		294,441	294,441	294,441
w/o project	$17.21	$5,067,325	$5,067,325	$5,067,325
w/project	$12.48	$3,674,621	$3,674,621	$3,674,621
Deferred Savings		$1,392,705	$1,392,705	$1,392,705
Decadal Factor		0.09629	0.04618	0.02215
		$134,104	$64,315	$30,848

Average Annual Savings: $955,134

Total Average Annual Savings $1,015,833

Projected Costs & Savings (1995-2015)

	Unit Cost	1988	1995	2005	2015
Tonnages		60,859	66,618	75,803	86,254
w/o project	$16.59	$1,009,651	$1,105,191	$1,257,569	$1,430,956
w/project	$14.25	$867,241	$949,305	$1,080,190	$1,229,121
Deferred Savings			$155,886	$177,379	$201,835
Decadal Factor			0.28293	0.41862	0.20077
			$44,105	$74,254	$40,522

Projected Costs & Savings (1995-2015)

	Unit Cost	2025	2035	2045
Tonnages		86,254	86,254	86,254
w/o project	$17.83	$1,537,829	$1,537,829	$1,537,829
w/project	$12.48	$1,076,451	$1,076,451	$1,076,451
Deferred Savings		$461,378	$461,378	$461,378
Decadal Factor		0.09629	0.04618	0.02215
		$44,426	$21,306	$10,220

Average Annual Savings: $60,699

Richmond Inner Harbor Project
39 Foot Project

Bauxite Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	30000	35	Australia	13,940	14	996	$517	$514,784	336	$425	$142,800	0	0	30000	$17.16	$4.76	$21.92

With Project Conditions (1995-2015) — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	38	Australia	13,940	14	996	$582	$579,506	336	$479	$160,944	0	0	40000	$14.49	$4.02	$18.51

With Project Conditions (2015-2045) — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	50000	40	Australia	13,940	14	996	$637	$634,270	336	$525	$176,400	0	0	50000	$12.69	$3.53	$16.21

Projected Costs & Savings (1995-2015)

	Unit Cost	1993	1995	2005	2015
Tonnage		90,892	114,860	160,463	224,171
Without Project	$21.92	$1,992,305	$2,517,675	$3,517,264	$4,913,720
With Project	$18.51	$1,682,524	$2,126,204	$2,970,369	$4,149,691
Deferred Savings		$309,781	$391,470	$546,895	$764,028
Decadal Factor			0.28293	0.41862	0.20077
			$110,759	$228,941	$153,394
Average Annual Savings:			$493,094		

Projected Costs & Savings (2015-2045)

	Unit Cost	2015	2025	2035	2045
Tonnage		224,171	313,174	313,174	313,174
Without Project	$21.92		$6,864,610	$6,864,610	$6,864,610
With Project	$16.21		$5,077,615	$5,077,615	$5,077,615
Deferred Savings			$1,786,995	$1,786,995	$1,786,995
Decadal Factor			0.09629	0.04618	0.02215
			$172,070	$82,523	$39,582
Average Annual Savings:			$294,175		

Total Average Annual Savings			$787,269		

Richmond Inner Harbor Project
39 Foot Project

Coke Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	35	Vlad, Russia	9,126	14	652	$582	$379,381	192	$479	$91,968	2	3145	36855	$10.29	$2.50	$12.79

With Project Conditions (1995-2015) — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	38	Vlad, Russia	9,126	14	652	$582	$379,381	192	$479	$91,968	0	0	40000	$9.48	$2.30	$11.78

With Project Conditions (2015-2045) — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	50000	40	Vlad, Russia	9,126	14	652	$637	$415,233	192	$525	$100,800	0	0	50000	$8.30	$2.02	$10.32

Projected Costs & Savings (1995-2015)

	Unit Cost	1995	2005	2015
Tonnage		216,508	246,359	280,326
w/o proj	$12.79	$2,768,981	$3,150,754	$3,585,167
with proj	$11.78	$2,551,270	$2,903,026	$3,303,283
Deferred Savings		$217,711	$247,728	$281,884
Decadal Factor		0.28293	0.41862	0.20077
		$61,597	$103,704	$56,594
Average Annual Savings:		$221,895		

Projected Costs & Savings (2015-2045)

	Unit Cost	2015	2025	2035	2045
Tonnage		280,326	318,976	318,976	318,976
w/o proj	$12.79	$3,585,167	$4,079,473	$4,079,473	$4,079,473
with proj	$10.32	$2,893,149	$3,292,043	$3,292,043	$3,292,043
Deferred Savings			$787,430	$787,430	$787,430
Decadal Factor			0.09629	0.04618	0.02215
			$75,822	$36,364	$17,442
Average Annual Savings:			$129,627		

Total Average Annual Savings $351,521

Richmond Inner Harbor Project
39 Foot Project

Gypsum Rock Benefit Calculations

Without Project Condition — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	26500	33	San Marcos I	3000	14	214	$494	$105,857	72	$406	$29,232	0	0	26500	$3.99	$1.10	$5.10

With Project Condition — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	35000	36	San Marcos I	3000	14	214	$548	$117,429	72	$451	$32,472	0	0	35000	$3.36	$0.93	$4.28

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		198,925	251,381	351,187	490,618	685,408	685,408	685,408
w/o project	$5.10	$1,014,061	$1,281,468	$1,790,248	$2,501,028	$3,494,008	$3,494,008	$3,494,008
w/project	$4.28	$851,971	$1,076,635	$1,504,090	$2,101,257	$2,935,517	$2,935,517	$2,935,517
Deferred Savings		$162,090	$204,833	$286,158	$399,771	$558,491	$558,491	$558,491
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$57,953	$119,791	$80,262	$53,777	$25,791	$12,371
Average Annual Savings:			$349,946					

Richmond Inner Harbor Project
39 Foot Project

Vegetable Oils Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port
	17000	32	Far East	14,000	14	1000	$722	$722,000	24	$567	$13,608
	25000	35	Far East	14,000	14	1000	$786	$786,000	24	$604	$14,496
	35000	37	Far East	14,000	16	875	$858	$750,750	24	$635	$15,240
	40000	38	Far East	14,000	16	875	$889	$777,875	24	$649	$15,576

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	32	0	0	17,000	$42.47	$0.80	$43.27
	25000	35	0	0	25,000	$31.44	$0.58	$32.02
	35000	37	1	1505	33,495	$22.41	$0.45	$22.87
	40000	38	2	3279	36,721	$21.18	$0.42	$21.61

With Project Conditions — 39 foot harbor

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	32			17,000	$42.47	$0.80	$43.27
	25000	35	0	0	25,000	$31.44	$0.58	$32.02
	35000	37	0	0	35,000	$21.45	$0.44	$21.89
	40000	38	0	0	40,000	$19.45	$0.39	$19.84

Without Project Conditions

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
				Projected Costs			
17000	$43.27	$10,341,590	$10,079,411	$9,702,596	$9,193,933	$9,193,933	$9,193,933
25000	$32.02	$3,826,300	$4,143,662	$4,487,347	$4,859,537	$4,859,537	$4,859,537
35000	$22.87	$1,639,675	$1,775,674	$2,563,936	$3,470,744	$3,470,744	$3,470,744
40000	$21.61	$1,032,832	$1,677,746	$1,816,902	$1,967,600	$1,967,600	$1,967,600
	Cost	$16,840,397	$17,676,493	$18,570,781	$19,491,814	$19,491,814	$19,491,814

With Project Conditions

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
				Projected Costs			
17000	$43.27	$9,307,431	$8,959,477	$8,489,772	$7,880,514	$5,253,676	$5,253,676
25000	$32.02	$3,826,300	$4,143,662	$4,487,347	$3,887,630	$4,859,537	$4,859,537
35000	$21.89	$1,569,156	$2,265,741	$2,208,300	$3,720,051	$3,720,051	$3,720,051
40000	$19.84	$1,422,234	$1,540,198	$2,446,320	$2,649,223	$3,251,320	$3,251,320
	Cost	$16,125,121	$16,909,077	$17,631,738	$18,137,418	$17,084,584	$17,084,584

Projected Savings

	1995	2005	2015	2025	2035	2045
Costs without Project	$16,840,397	$17,676,493	$18,570,781	$19,491,814	$19,491,814	$19,491,814
Costs with Project	$16,125,121	$16,909,077	$17,631,738	$18,137,418	$17,084,584	$17,084,584
Savings	$715,276	$767,416	$939,043	$1,354,396	$2,407,231	$2,407,231
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$202,373	$321,256	$188,532	$130,415	$111,166	$53,320

Ave. Annual Benefits $1,007,061

Richmond Inner Harbor Project
39 Foot Project

Jet Fuel Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30000	34	Gulf of Mexico	3000	14	214	$1,665	$356,786	24	$1,573	$37,752	30000	$11.89	$1.26	$13.15

With Project Conditions — 39 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	50000	40	Gulf of Mexico	3000	14	214	$2,003	$429,214	24	$1,891	$45,384	50000	$8.58	$0.91	$9.49

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		111,940	143,385	204,221	290,870	414,282	414,282	414,282
w/o project	$13.15	$1,472,152	$1,885,692	$2,685,767	$3,825,304	$5,448,329	$5,448,329	$5,448,329
w/project	$9.49	$1,062,531	$1,361,005	$1,938,462	$2,760,927	$3,932,351	$3,932,351	$3,932,351
Deferred Savings		$409,621	$524,687	$747,305	$1,064,378	$1,515,979	$1,515,979	$1,515,979
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$148,450	$312,837	$213,695	$145,974	$70,008	$33,579
Average Annual Savings:			$924,542					

Richmond Inner Harbor Project
39 Foot Project

Petroleum Products Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	25000	32	Cherry Pt.	1600	14	114	$1,574	$179,886	24	$1,487	$35,688	0	0	25000	$7.20	$1.43	$8.62
	35000	35	Cherry Pt.	1600	14	114	$1,757	$200,800	24	$1,659	$39,816	0	0	35000	$5.74	$1.14	$6.87
	40000	37	Cherry Pt.	1600	14	114	$1,839	$210,171	24	$1,737	$41,688	1	1626	38374	$5.48	$1.09	$6.56

With Project Conditions — 40 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	25000	32	Cherry Pt.	1600	14	114	$1,574	$179,886	24	$1,487	$35,688	0	0	25000	$7.20	$1.43	$8.62
	35000	35	Cherry Pt.	1600	14	114	$1,757	$200,800	24	$1,659	$39,816	0	0	35000	$5.74	$1.14	$6.87
	40000	37	Cherry Pt.	1600	14	114	$1,839	$210,171	24	$1,737	$41,688	0	0	40000	$5.25	$1.04	$6.30

Without Project Conditions

Projected Tonnages

DWT	1988	1995	2005	2015	2025	2035	2045
25000	148,361	178,160	225,556	281,100	400,367	488,775	696,156
35000	74,181	98,978	169,167	240,943	343,172	570,238	696,156
40000	86,544	118,773	169,167	281,100	400,367	570,238	928,208
Total	309,086	395,911	563,891	803,143	1,143,906	1,629,250	2,320,520

Projected Costs

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,536,264	$1,944,961	$2,423,910	$3,452,344	$4,214,683	$6,002,918
35000	$6.87	$680,447	$1,162,982	$1,656,420	$2,359,218	$3,920,237	$4,785,894
40000	$6.56	$779,548	$1,110,300	$1,844,950	$2,627,739	$3,742,655	$6,092,131
Total Costs		$2,996,259	$4,218,243	$5,925,281	$8,439,301	$11,877,574	$16,880,944

With Project Conditions

Projected Tonnages

DWT	1988	1995	2005	2015	2025	2035	2045
25000	148,361	158,364	197,362	240,943	285,976	407,313	580,130
35000	74,181	118,773	169,167	281,100	400,367	570,238	696,156
40000	86,544	118,773	197,362	281,100	457,562	651,700	1,044,234
Total	309,086	395,911	563,891	803,143	1,143,906	1,629,250	2,320,520

Projected Costs

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,365,568	$1,701,841	$2,077,638	$2,465,960	$3,512,236	$5,002,432
35000	$6.87	$816,536	$1,162,982	$1,932,490	$2,752,421	$3,920,237	$4,785,894
40000	$6.30	$747,854	$1,242,686	$1,769,942	$2,881,035	$4,103,421	$6,575,006
Costs		$2,929,959	$4,107,509	$5,780,069	$8,099,416	$11,535,894	$16,363,332

Projected Costs & Savings

	1995	2005	2015	2025	2035	2045
Costs w/o Project	$2,996,259	$4,218,243	$5,925,281	$8,439,301	$11,877,574	$16,880,944
Costs with Project	$2,929,959	$4,107,509	$5,780,069	$8,099,416	$11,535,894	$16,363,332
Savings	$66,300	$110,734	$145,211	$339,885	$341,681	$517,612
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$18,758	$46,355	$29,154	$32,728	$15,779	$11,465

Average Annual Savings $154,239

BENEFIT CALCULATIONS

40-FOOT PROJECT

Tidal Delay Calculations
40-foot project

Without project	Projected Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045	Tidal Delay (feet)	Tidal Delay (hours)	Tidal Delay Cost	Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	3	4	5	7	7	7	3	11.4	$736	$1,910	$2,668	$3,728	$5,208	$5,208	$5,208
Scrap Metal	7	8	9	10	11	11	11	3	11.4	$736	$5,542	$6,306	$7,175	$8,165	$8,165	$8,165
Scrap II	2	2	2	3	3	3	3	5	21.5	$4,557	$8,939	$10,171	$11,574	$13,169	$13,169	$13,169
Coke	5	5	6	6	6	6	6	4	15.6	$1,264	$6,700	$6,973	$7,257	$7,552	$7,552	$7,552
Bauxite	3	4	5	7	10	10	10	4	15.6	$1,264	$4,839	$6,761	$9,445	$13,195	$13,195	$13,195
Gypsum	8	9	13	19	26	26	26	4	15.6	$1,264	$11,990	$16,751	$23,402	$32,693	$32,693	$32,693
Veg oils																
17000	16	14	14	13	12	12	12	1	4	$237	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	4	5	5	6	6	6	6	4	15.6	$1,901	$9,087	$9,840	$10,656	$11,540	$11,540	$11,540
35000	1	2	2	3	4	4	4	5	21.5	$6,854	$14,041	$15,205	$21,955	$29,720	$29,720	$29,720
40000	1	1	2	2	2	2	2	5	21.5	$6,854	$8,190	$13,305	$14,408	$15,603	$15,603	$15,603
Jet Fuel	4	5	7	10	14	14	14	3	11.4	$2,597	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
Petroleum																
25000	6	7	9	11	16	16	16	1	4	$557	$3,969	$5,025	$6,263	$8,920	$8,920	$8,920
35000	2	3	5	7	10	10	10	4	15.6	$1,255	$3,549	$6,066	$8,640	$12,305	$12,305	$12,305
40000	2	3	4	7	10	10	10	5	21.5	$15,444	$45,858	$65,315	$108,533	$154,582	$154,582	$154,582

With Project	Projected Number of Vessel Trips 1988	1995	2005	2015	2025	2035	2045				Projected Tidal Delay Costs 1995	2005	2015	2025	2035	2045
Cement	2	2	2	3	4	4	4	2	6	$356	$554	$774	$1,082	$1,511	$1,511	$1,511
Scrap Metal	7	4	5	5	6	6	6	2	6	$356	$1,423	$1,619	$1,842	$2,096	$2,096	$2,096
Scrap II	2	1	2	2	2	2	2	2	6	$356	$474	$540	$614	$699	$699	$699
Coke	5	4	5	6	6	6	6	0	0	$0	$0	$0	$0	$0	$0	$0
Bauxite	3	2	3	4	6	6	6	2	6	$356	$818	$1,142	$1,596	$2,230	$2,230	$2,230
Gypsum	8	7	10	14	20	20	20	2	6	$356	$2,557	$3,572	$4,990	$6,972	$6,972	$6,972
Veg oils																
17000	16	13	12	12	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
25000	4	5	5	6	5	5	5	0	0	$0	$0	$0	$0	$0	$0	$0
35000	1	2	3	3	5	5	5	0	0	$0	$0	$0	$0	$0	$0	$0
40000	1	2	2	3	3	3	3	0	0	$0	$0	$0	$0	$0	$0	$0
Jet Fuel	4	3	4	5	7	7	7	1	4	$534	$1,371	$1,952	$2,781	$3,960	$3,960	$3,960
Petroleum																
25000	6	6	8	10	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
35000	2	3	5	8	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0
40000	2	3	5	7	11	11	11	0	0	$0	$0	$0	$0	$0	$0	$0

PROJECTED SAVINGS

	1995	2005	2015	2025	2035	2045
Cement	$1,356	$1,894	$2,646	$3,696	$3,696	$3,696
Scrap Metal	$4,119	$4,687	$5,333	$6,068	$6,068	$6,068
Scrap II	$8,465	$9,632	$10,960	$12,471	$12,471	$12,471
Coke	$6,700	$6,973	$7,257	$7,552	$7,552	$7,552
Bauxite	$4,022	$5,618	$7,849	$10,965	$10,965	$10,965
Gypsum	$9,434	$13,179	$18,411	$25,721	$25,721	$25,721
Veg oils	$0	$0	$0	$0	$0	$0
17000	$3,332	$3,247	$3,126	$2,962	$2,962	$2,962
25000	$9,087	$9,840	$10,656	$11,540	$11,540	$11,540
35000	$14,041	$15,205	$21,955	$29,720	$29,720	$29,720
40000	$8,190	$13,305	$14,408	$15,603	$15,603	$15,603
Jet Fuel	$1,961	$1,295	$345	($998)	($998)	($998)
Petroleum	$0	$0	$0	$0	$0	$0
25000	$3,969	$5,025	$6,263	$8,920	$8,920	$8,920
35000	$3,549	$6,066	$8,640	$12,305	$12,305	$12,305
40000	$45,858	$65,315	$108,533	$154,582	$154,582	$154,582
Total	$124,082	$161,282	$226,382	$301,108	$301,108	$301,108
Decadal Factor	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$35,106	$67,516	$45,451	$28,994	$13,905	$6,670
Total Tidal Savings		$197,641				

Richmond Inner Harbor Porject
40 Foot Project

Cement Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30,000	34	Mexico	3,100	14	221	$517	$114,479	72	$425	$30,600	$3.82	$1.02	$4.84

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea (hrs)	Cost/hr Sea	Cost at Sea	Time in Port (hrs)	Cost/hr Port	Cost at Port	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	50,000	40	Mexico	3,100	14	221	$637	$141,050	72	$525	$37,800	$2.82	$0.76	$3.58

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnages		61,609	77,855	108,766	151,949	212,278	212,278	212,278
Without Project	$4.84		$376,504	$525,987	$734,820	$1,026,564	$1,026,564	$1,026,564
With Project	$3.58		$278,488	$389,056	$543,523	$759,317	$759,317	$759,317
Deferred Savings			$98,016	$136,931	$191,297	$267,247	$267,247	$267,247
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$27,732	$57,322	$38,407	$25,733	$12,341	$5,920
Average Annual Savings:			$167,455					

Richmond Inner Harbor Project
40 Foot Project

Bauxite Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	30000	35	Australia	13,940	14	996	$517	$514,784	336	$425	$142,800	0	0	30000	$17.16	$4.76	$21.92

With Project Conditions (1995-2015) — 40 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	38	Australia	13,940	14	996	$582	$579,506	336	$479	$160,944	0	0	40000	$14.49	$4.02	$18.51

With Project Conditions (2015-2045) — 40 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	50000	40	Australia	13,940	14	996	$637	$634,270	336	$525	$176,400	0	0	50000	$12.69	$3.53	$16.21

Projected Costs & Savings (1995-2015)

	Unit Cost	1993	1995	2005	2015
Tonnage		90,892	114,860	160,463	224,171
Without Project	$21.92	$1,992,305	$2,517,675	$3,517,264	$4,913,720
With Project	$18.51	$1,682,524	$2,126,204	$2,970,369	$4,149,691
Deferred Savings		$309,781	$391,470	$546,895	$764,028
Decadal Factor			0.28293	0.41862	0.20077
			$110,759	$228,941	$153,394
Average Annual Savings:			$493,094		

Projected Costs & Savings (2015-2045)

	Unit Cost	2015	2025	2035	2045
Tonnage		224,171	313,174	313,174	313,174
Without Project	$21.92		$6,864,610	$6,864,610	$6,864,610
With Project	$16.21		$5,077,615	$5,077,615	$5,077,615
Deferred Savings			$1,786,995	$1,786,995	$1,786,995
Decadal Factor			0.09629	0.04618	0.02215
			$172,070	$82,523	$39,582
Average Annual Savings:			$294,175		

Total Average Annual Savings $787,269

Richmond Inner Harbor Project
40 Foot Project

Coke Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	35	Vlad, Russia	9,126	14	652	$582	$379,381	192	$479	$91,968	2	3145	36855	$10.29	$2.50	$12.79

With Project Conditions (1995-2015) 40 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	40000	38	Vlad, Russia	9,126	14	652	$582	$379,381	192	$479	$91,968	0	0	40000	$9.48	$2.30	$11.78

With Project Conditions (2015-2045) 40 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Loaded (ft)	Tons Light Loaded	Actual Tons Carried	Cost/Ton @ Sea	Cost/Ton @Port	Total Unit Cost
	50000	40	Vlad, Russia	9,126	14	652	$637	$415,233	192	$525	$100,800	0	0	50000	$8.30	$2.02	$10.32

Projected Costs & Savings (1995-2015)

	Unit Cost	1995	2005	2015
Tonnage		216,508	246,359	280,326
w/o proj	$12.79	$2,768,981	$3,150,754	$3,585,167
with proj	$11.78	$2,551,270	$2,903,026	$3,303,283
Deferred Savings		$217,711	$247,728	$281,884
Decadal Factor		0.28293	0.41862	0.20077
		$61,597	$103,704	$56,594
Average Annual Savings:		$221,895		

Projected Costs & Savings (2015-2045)

	Unit Cost	2015	2025	2035	2045
Tonnage		280,326	318,976	318,976	318,976
w/o proj	$12.79	$3,585,167	$4,079,473	$4,079,473	$4,079,473
with proj	$10.32	$2,893,149	$3,292,043	$3,292,043	$3,292,043
Deferred Savings			$787,430	$787,430	$787,430
Decadal Factor			0.09629	0.04618	0.02215
			$75,822	$36,364	$17,442
Average Annual Savings:			$129,627		
Total Average Annual Savings			$351,521		

Richmond Inner Harbor Project
40 Foot Project

Gypsum Rock Benefit Calculations

Without Project Condition

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time In Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea'	Cost/Ton @Port	Total Unit Cost
	26500	33	San Marcos I	3000	14	214	$494	$105,857	72	$406	$29,232	0	0	26500	$3.99	$1.10	$5.10

With Project Condition

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time In Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	35000	36	San Marcos I	3000	14	214	$548	$117,429	72	$451	$32,472	0	0	35000	$3.36	$0.93	$4.28

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		198,925	251,381	351,187	490,618	685,408	685,408	685,408
w/o project	$5.10	$1,014,061	$1,281,468	$1,790,248	$2,501,028	$3,494,008	$3,494,008	$3,494,008
w/project	$4.28	$851,971	$1,076,635	$1,504,090	$2,101,257	$2,935,517	$2,935,517	$2,935,517
Deferred Savings		$162,090	$204,833	$286,158	$399,771	$558,491	$558,491	$558,491
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$57,953	$119,791	$80,262	$53,777	$25,791	$12,371
Average Annual Savings:			$349,946					

Richmond Inner Harbor Project
40 Foot Project

Vegetable Oils Benefit Calculations

Baseline Data

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port
	17000	32	Far East	14,000	14	1000	$722	$722,000	24	$567	$13,608
	25000	35	Far East	14,000	14	1000	$786	$786,000	24	$604	$14,496
	35000	37	Far East	14,000	16	875	$858	$750,750	24	$635	$15,240
	40000	38	Far East	14,000	16	875	$889	$777,875	24	$649	$15,576

Without Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	32			17,000	$42.47	$0.80	$43.27
	25000	35	0	0	25,000	$31.44	$0.58	$32.02
	35000	37	1	1505	33,495	$22.41	$0.45	$22.87
	40000	38	2	3279	36,721	$21.18	$0.42	$21.61

With Project Conditions

Vessel	DWT	Max Des Draft	Light Load (ft)	Tons Light Load	Actual Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	17000	32	0	0	17,000	$42.47	$0.80	$43.27
	25000	35	0	0	25,000	$31.44	$0.58	$32.02
	35000	37	0	0	35,000	$21.45	$0.44	$21.89
	40000	38	0	0	40,000	$19.45	$0.39	$19.84

Without Project Conditions

		Projected Costs					
DWT	Unit Cost	1995	2005	2015	2025	2035	2045
17000	$43.27	$10,341,337	$10,079,165	$9,702,359	$9,193,708	$9,193,708	$9,193,708
25000	$32.02	$3,826,319	$4,143,682	$4,487,369	$4,859,562	$4,859,562	$4,859,562
35000	$22.87	$1,639,675	$1,775,674	$2,563,936	$3,470,744	$3,470,744	$3,470,744
40000	$21.61	$1,032,832	$1,677,746	$1,816,902	$1,967,600	$1,967,600	$1,967,600
Cost		$16,840,163	$17,676,267	$18,570,566	$19,491,614	$19,491,614	$19,491,614

With Project Conditions

		Projected Costs					
DWT	Unit Cost	1995	2005	2015	2025	2035	2045
17000	$43.27	$9,307,431	$8,959,477	$8,489,775	$7,880,514	$5,253,676	$5,253,676
25000	$32.02	$3,826,300	$4,143,662	$4,487,348	$3,887,630	$4,859,537	$4,859,537
35000	$21.89	$1,569,156	$2,265,741	$2,085,617	$3,587,192	$3,720,051	$3,587,192
40000	$19.84	$1,422,234	$1,540,198	$2,557,517	$2,769,643	$3,251,320	$3,371,739
Cost		$16,125,121	$16,909,077	$17,620,258	$18,124,978	$17,084,584	$17,072,144

	Projected Savings					
	1995	2005	2015	2025	2035	2045
Costs without Project						
Costs with Project	$16,840,163	$17,676,267	$18,570,566	$19,491,614	$19,491,614	$19,491,614
Savings	$16,125,121	$16,909,077	$17,620,258	$18,124,978	$17,084,584	$17,072,144
Decadal Factor	$715,042	$767,190	$950,308	$1,366,635	$2,407,030	$2,419,470
	0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
	$202,307	$321,161	$190,793	$131,593	$111,157	$53,591

Average Annual Benefits $1,010,602

Richmond Inner Harbor Project
40 Foot Project

Petroleum Benefit Calculations

Without Project Conditions — 35 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	25000	32	Cherry Pt.	1600	14	114	$1,574	$179,886	24	$1,487	$35,688	0	0	25000	$7.20	$1.43	$8.62
	35000	35	Cherry Pt.	1600	14	114	$1,757	$200,800	24	$1,659	$39,816	0	0	35000	$5.74	$1.14	$6.87
	40000	37	Cherry Pt.	1600	14	114	$1,839	$210,171	24	$1,737	$41,688	1	1626	38374	$5.48	$1.09	$6.56

With Project Conditions — 40 foot harbor

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	25000	32	Cherry Pt.	1600	14	114	$1,574	$179,886	24	$1,487	$35,688	0	0	25000	$7.20	$1.43	$8.62
	35000	35	Cherry Pt.	1600	14	114	$1,757	$200,800	24	$1,659	$39,816	0	0	35000	$5.74	$1.14	$6.87
	60000	43	Cherry Pt.	1600	14	114	$2,149	$245,600	24	$2,030	$48,720	2	4,140	55860	$4.40	$0.87	$5.27

Without Project Conditions — 35 foot harbor

Projected Costs

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,536,264	$1,944,961	$2,423,910	$3,452,344	$3,452,344	$3,452,344
35000	$6.87	$680,447	$1,162,982	$1,656,420	$2,359,218	$2,359,218	$2,359,218
40000	$6.56	$779,548	$1,110,300	$1,844,950	$2,627,739	$2,627,739	$2,627,739
Total Costs		$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301

With Project Conditions — 40 foot harbor

Projected Costs

DWT	Unit Cost	1995	2005	2015	2025	2035	2045
25000	$8.62	$1,365,568	$1,701,841	$2,077,638	$2,465,960	$2,465,960	$2,465,960
35000	$6.87	$816,536	$1,162,982	$1,932,490	$2,752,421	$2,752,421	$2,752,421
40000	$5.27	$625,798	$1,039,868	$1,481,071	$2,410,823	$2,410,823	$2,410,823
Costs		$2,807,902	$3,904,691	$5,491,198	$7,629,204	$7,629,204	$7,629,204

Projected Costs & Savings

	1995	2005	2015	2025	2035	2045
Costs w/o Project	$2,996,259	$4,218,243	$5,925,281	$8,439,301	$8,439,301	$8,439,301
Costs with Project	$2,807,902	$3,904,691	$5,491,198	$7,629,204	$7,629,204	$7,629,204
Savings	$188,357	$313,552	$434,082	$810,097	$810,097	$810,097
Decadal Factor	0.28203	0.41862	0.20077	0.09629	0.04618	0.02215
	$53,202	$131,259	$87,151	$78,004	$37,410	$17,944

Average Annual Savings $405,060

Richmond Inner Harbor Project
40 Foot Project

Jet Fuel Benefit Calculations

Without Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	30000	34	Gulf of Mexico	3000	14	214	$1,665	$356,786	24	$1,573	$37,752	0	2,742	30000	$11.89	$1.26	$13.15

With Project Conditions

Vessel	DWT	Max Des Draft	Origin/ Destination	Distance	Speed	Time at Sea	Cost/hr Sea	Cost at Sea	Time in Port	Cost/hr Port	Cost at Port	Light Load (ft)	Tons Light Load	Tons Carried	Cost/Ton @Sea	Cost/Ton @Port	Total Unit Cost
	60000	42	Gulf of Mexico	3000	14	214	$2,149	$460,500	24	$2,030	$48,720	2	4,140	55860	$8.24	$0.87	$9.12

Projected Costs & Savings

	Unit Cost	1988	1995	2005	2015	2025	2035	2045
Tonnage		111,940	143,385	204,221	290,870	414,282	414,282	414,282
w/o project	$13.15	$1,472,152	$1,885,692	$2,685,767	$3,825,304	$5,448,331	$5,448,331	$5,448,331
w/project	$9.12	$1,020,437	$1,307,087	$1,861,667	$2,651,548	$3,776,566	$3,776,566	$3,776,566
Deferred Savings		$451,715	$578,606	$824,101	$1,173,756	$1,671,766	$1,671,766	$1,671,766
Decadal Factor			0.28293	0.41862	0.20077	0.09629	0.04618	0.02215
			$163,705	$344,985	$235,655	$160,974	$77,202	$37,030
Average Annual Savings:			$1,019,551					

Appendix E

Cost Estimates

Please Note:

Throughout this appendix 30—Planning, Engineering & Design, E&D, Sunk—the cost is $9,103,000 instead of $9,200,000.

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
MONTEZUMA ALTERNATIVE A
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
12------	NAVIGATION, PORTS & HARBORS	$23,912,192	$1,819,779	$25,731,971	$771,959	$26,503,930
30------	PLANNING, ENGINEERING & DESIGN	$9,436,900	$0	$9,436,900	$283,107	$9,720,007
31------	CONSTRUCTION MANAGEMENT	$540,750	$0	$540,750	$16,223	$556,973
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$33,926,790	$1,825,321	$35,752,111	$1,072,563	$36,824,674
NON-FEDERAL COSTS						
12------	NAVIGATION, PORTS & HARBORS	$1,407,853	$86,228	$1,494,081	$44,822	$1,538,903
FEDERAL & NON-FEDERAL COSTS, TOTAL		$35,334,643	$1,911,549	$37,246,192	$1,117,386	$38,363,578

U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
MONTEZUMA ALTERNATIVE A							
FEDERAL COSTS							
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120201-- Mobilization & Demobilization, Contingency 25%, Reason 1/							
Mob & Demob, Clamshell	1.00	JOB	848,980	25,469	218,612	1,093,062	1093062
120215-- Clamshell Dredging, Contingency 15%, Reason 2/							
SOFT DREDGING & MONTEZUMA DISP.							
Dredging, Clamshell	1597000	CY	7,489,930	224,698	1,157,194	8,871,822	5.56
Tipping Fee	1597000	CY	11,179,000	0	0	11,179,000	7.00
TOTAL SOFT DREDGING & MONTEZUMA DISP.	1597000	CY	18,668,930	224,698	1,157,194	20,050,822	12.56
HARD DREDGING & MONTEZUMA DISP.							
Dredging, Clamshell	196000.00	CY	2,299,080	68,972	355,208	2,723,260	13.89
Tipping Fee	196000.00	CY	1,372,000	0	0	1,372,000	7.00
TOTAL HARD DREDGING & MONTEZUMA DISP.	196000.00	CY	3,671,080	68,972	355,208	4,095,260	20.89
120215-- Clamshell Dredging, Contingency 25%, Reason 4/							
UNDERWATER ROCK EXCAVATION							
Rock Excavation & Disposal	7000.00	CY	244,720	7,342	63,015	315,077	45.01
Tipping Fee	7000.00	CY	49,000	0	0	49,000	7.00
TOTAL UNDERWATER ROCK EXCAVATION	7000.00	CY	293,720	7,342	63,015	364,077	52.01
120299-- Associated General Items, Contingency 25%, Reason 3/							
AIDS TO NAVIGATION	1.00	JOB	100,000	3,000	25,750	128,750	128750.00
30------ PLANNING, ENGINEERING & DESIGN							
E&D							
E&D, Dredging	1.00	JOB	230,000	6,900	0	236,900	236900.00
E&D, Sunk	1.00	JOB	9,200,000	0	0	9,200,000	9200000
TOTAL E&D	1.00	JOB	9,430,000	6,900	0	9,436,900	9436900
31------ CONSTRUCTION MANAGEMENT (S&I)							
SIOH, Dredging	7.00	MO	525,000	15,750	0	540,750	77250.00
OPERATIONS & MAINTENANCE	11210.00	CY	35,872	1,076	5,542	42,490	3.79
TOTAL FEDERAL COSTS	1.00	JOB	35,573,582	353,207	1,825,322	35,752,111	35752111

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
MONTEZUMA ALTERNATIVE A							
NON-FEDERAL COSTS							
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120201-- Mobilization & Demobilization, Contingency 15%, Reason 2/							
SOFT DREDGING & MONTEZUMA DISP							
6C, 6D, 7							
Dredging, Clamshell	23000.00	CY	107,870	3,236	16,666	127,772	5.56
Tipping Fee	23000.00	CY	161,000	0	0	161,000	7.00
TOTAL 6C, 6D, 7	23000.00	CY	268,870	3,236	16,666	288,772	12.56
TERM 2							
Dredging, Clamshell	22000.00	CY	103,180	3,095	15,941	122,217	5.56
Tipping Fee	22000.00	CY	154,000	0	0	154,000	7.00
TOTAL TERM 2	22000.00	CY	257,180	3,095	15,941	276,217	12.56
TERM 3							
Dredging, Clamshell	15000.00	CY	70,350	2,111	10,869	83,330	5.56
Tipping Fee	15000.00	CY	105,000	0	0	105,000	7.00
TOTAL TERM 3	15000.00	CY	175,350	2,111	10,869	188,330	12.56
ARCO							
Dredging, Clamshell	15000.00	CY	70,350	2,111	10,869	83,330	5.56
Tipping Fee	15000.00	CY	105,000	0	0	105,000	7.00
TOTAL ARCO	15000.00	CY	175,350	2,111	10,869	188,330	12.56
GATX							
Dredging, Clamshell	15000.00	CY	70,350	2,111	10,869	83,330	5.56
Tipping Fee	15000.00	CY	105,000	0	0	105,000	7.00
TOTAL GATX	15000.00	CY	175,350	2,111	10,869	188,330	12.56
GOLD BOND							
Dredging, Clamshell	5000.00	CY	23,450	704	3,623	27,777	5.56
Tipping Fee	5000.00	CY	35,000	0	0	35,000	7.00
TOTAL GOLD BOND	5000.00	CY	58,450	704	3,623	62,777	12.56
LEVIN							
Dredging, Clamshell	11000.00	CY	51,590	1,548	7,971	61,108	5.56
Tipping Fee	11000.00	CY	77,000	0	0	77,000	7.00
TOTAL LEVIN	11000.00	CY	128,590	1,548	7,971	138,108	12.56

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U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
MONTEZUMA ALTERNATIVE A							
NON-FEDERAL COSTS							
TEXACO							
Dredging, Clamshell	5000.00	CY	23,450	704	3,623	27,777	5.56
Tipping Fee	5000.00	CY	35,000	0	0	35,000	7.00
TOTAL TEXACO	5000.00	CY	58,450	704	3,623	62,777	12.56
TIME OIL							
Dredging, Clamshell	5000.00	CY	23,450	704	3,623	27,777	5.56
Tipping Fee	5000.00	CY	35,000	0	0	35,000	7.00
TOTAL TIME OIL	5000.00	CY	58,450	704	3,623	62,777	12.56
UNOCAL							
Dredging, Clamshell	3000.00	CY	14,070	422	2,174	16,666	5.56
Tipping Fee	3000.00	CY	21,000	0	0	21,000	7.00
TOTAL UNOCAL	3000.00	CY	35,070	422	2,174	37,666	12.56
TOTAL SOFT DREDGING & MONTEZUMA DISP	119000.00	CY	1,391,110	16,743	86,228	1,494,081	12.56
TOTAL NON-FEDERAL COSTS	1.00	JOB	1,391,110	16,743	86,228	1,494,081	1494081
TOTAL MONTEZUMA ALTERNATIVE A	1.00	JOB	34,964,692	369,951	1,911,550	37,246,193	37246193

BASIS OF COST
MONTEZUMA ALTERNATIVE A

1. Project Description: The project consists of deepening Richmond Harbor to a project depth of -38 feet mean lower low water with a tolerance (overdepth) of 1 foot below project depth, except for areas of hard material where dredging will be -38 feet plus 1 foot overdepth and up to one foot of tolerance.

Approximately 1,716,000 cubic yards of soft material, 196,000 cubic yards of hard material and 7,000 cubic yards of underwater rock would be dredged and deposited at the Montezuma upland disposal site.

2. Pricing is based on the January 1996 price level. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (Costs have been escalated from the previous January 1995 price level using an escalation factor of +3.0%). The estimate assumes that the Contractor will be working 24 hours a day, 7 days a week.

3. For disposal at the Montezuma disposal site, a tipping fee of $7.00 per cubic yard is assumed based on statements from the landowner and local sponsor. The tipping fee would cover site preparation, monitoring, and the unloading and spreading of material.

4. The estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract by a prime contractor who will execute all the dredging, hauling and disposal operations unless noted otherwise.

5. Mobilization and demobilization for plant and equipment is based on the preparation, transfer, set-up and removal of plant and equipment required. It is assumed that moblilization and demoblization of all equipment can be completed in 14 days.

6. Dredging would be performed by a 20 cy clamshell dredge, 6-4,000 c.y. bottom dump scows, 5-1,200 Hp hauling tugs, 1-850 Hp support tug, and other support equipment. The number of scows required is determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. The dredge/haul production rate is approximately 560 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month). Barges would be filled to 80% capacity and no overflow is allowed. Tugboat speed for the round trip is assumed to be 6 knots average speed.

7. Underwater rock would be excavated using the same clamshell plant and equipment, with a 9 cy bucket. Production rate would be approximately 70 cy/hr.

8. Hauling distance from the dredge site to the Montezuma disposal site is approximately 44 miles.

9. Construction Time. The project can be completed in 7 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

MONTEZUMA ALTERNATIVE A

Contingency Footnotes:

1/ Mobilization and demobilization costs are dependent on the location and availability of plant and equipment at the time the project is bid. A project of this magnitude will likely attract bidders from the East Coast. Availability of plant and equipment may be impacted by other jobs in progress in the local area such as annual maintenance dredging and the Oakland Harbor deepening project which will be in progress when this project is scheduled to commence.

2/ Clamshell dredging costs are dependent on the characteristics of the material to be dredged which affects production rates. Other unknown factors which will affect the dredging costs are marine traffic and weather conditions.

3/ Aids to navigation cost is dependent on the number of buoys and markers to be relocated and the number of safety markers to be installed during the project in accordance with marine regulations and as directed by the Coast Guard.

4/ Rock removal costs are dependent by the amount and condition of the rock. The information on the amount of rock is preliminary and no information is available on the effort necessary to break the rock.

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
MONTEZUMA/PARKING LOT ALTERNATIVE A1
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
01------	LANDS & DAMAGES	$89,100	$0	$89,100	$2,138 *	$91,238
12------	NAVIGATION, PORTS & HARBORS	$22,856,175	$1,826,793	$24,682,968	$740,489	$25,423,457
30------	PLANNING, ENGINEERING & DESIGN	$9,493,550	$0	$9,493,550	$284,807	$9,778,357
31------	CONSTRUCTION MANAGEMENT	$540,750	$0	$540,750	$16,223	$556,973
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$33,016,523	$1,832,335	$34,848,858	$1,044,931	$35,893,789
NON-FEDERAL COSTS						
01------	LANDS & DAMAGES	$1,225,000	$0	$1,225,000	$29,400 *	$1,254,400
12------	NAVIGATION, PORTS & HARBORS	$1,453,979	$66,946	$1,520,925	$45,628	$1,566,553
NON-FEDERAL COSTS, TOTAL		$2,678,979	$66,946	$2,745,925	$75,028	$2,820,953
FEDERAL & NON-FEDERAL COSTS, TOTAL		$35,695,502	$1,899,281	$37,594,783	$1,119,959	$38,714,742

*Real Estate costs are escalated to the Certification date for LERRDS, 7/96.

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** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
MONTEZUMA/PARKING LOT ALT A1							
FEDERAL COSTS							
01------ LANDS AND DAMAGES, PARKING LOT							
Federal Review	1.00	JOB	89,100	0	0	89,100	89100.00
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120201-- Mobilization & Demobilization, Contingency 25%, Reason 1/							
Mob & Demob, Clamshell	1.00	JOB	996,975	29,909	256,721	1,283,605	1283605
120215-- Clamshell Dredging, Contingency 15%, Reason 2/							
SOFT DREDGING & MONTEZUMA DISP							
Dredging, Clamshell	1473000	CY	6,908,370	207,251	1,067,343	8,182,964	5.56
Tipping Fee	1473000	CY	10,311,000	0	0	10,311,000	7.00
TOTAL SOFT DREDGING & MONTEZUMA DISP	1473000	CY	17,219,370	207,251	1,067,343	18,493,964	12.56
SOFT DREDGING & PARKING LOT DISP							
Dredging, Clamshell	123000.00	CY	416,970	12,509	64,422	493,901	4.02
TOTAL SOFT DREDGING & PARKING LOT DISP	123000.00	CY	416,970	12,509	64,422	493,901	4.02
HARD DREDGING & MONTEZUMA DISP							
Dredging, Clamshell	181000.00	CY	2,123,130	63,694	328,024	2,514,847	13.89
Tipping Fee	181000.00	CY	1,267,000	0	0	1,267,000	7.00
TOTAL HARD DREDGING & MONTEZUMA DISP	181000.00	CY	3,390,130	63,694	328,024	3,781,847	20.89
HARD DREDGING & PARKING LOT DISP							
Dredging, Clamshell	15000.00	CY	189,900	5,697	29,340	224,937	15.00
120215-- Clamshell Dredging, Contingency 25%, Reason 4/							
Rock Excavation and Disposal	7000.00	CY	214,340	6,430	55,193	275,963	39.42
120299-- Associated General Items, Contingency 25%, Reason 3/							
AIDS TO NAVIGATION	1.00	JOB	100,000	3,000	25,750	128,750	128750.00
30------ PLANNING, ENGINEERING & DESIGN							
E&D							
E&D, Dredging	1.00	JOB	230,000	6,900	0	236,900	236900.00
E&D, Parking Lot	1.00	JOB	55,000	1,650	0	56,650	56650.00
E&D, Sunk	1.00	JOB	9,200,000	0	0	9,200,000	9200000
TOTAL E&D	1.00	JOB	9,485,000	8,550	0	9,493,550	9493550

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Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
MONTEZUMA/PARKING LOT ALT A1							
FEDERAL COSTS							
31------ CONSTRUCTION MANAGEMENT (S&I)							
SIOH, Dredging	7.00	MO	525,000	15,750	0	540,750	77250.00
OPERATIONS & MAINTENANCE	11210.00	CY	35,872	1,076	5,542	42,490	3.79
TOTAL FEDERAL COSTS	1.00	JOB	32,662,657	353,867	1,832,334	34,848,858	34848858

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** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
MONTEZUMA/PARKING LOT ALT A1							
NON-FEDERAL COSTS							
01------ LANDS AND DAMAGES, PARKING LOT							
Non-Federal Review	1.00	JOB	15,000	0	0	15,000	15000
Lands (LERRDS)	1.00	JOB	1,210,000	0	0	1,210,000	1210000
01------ TOTAL LANDS AND DAMAGES, PARKING LOT	1.00	JOB	1,225,000	0	0	1,225,000	1225000
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120215-- Clamshell Dredging, Contingency 15%, Reason 2/ DREDGING & PARKING LOT DISPOSAL							
TERM 2 Dredging, Clamshell	22000.00	CY	74,580	2,237	11,523	88,340	4.02
TERM 3 Dredging, Clamshell	15000.00	CY	50,850	1,526	7,856	60,232	4.02
ARCO Dredging, Clamshell	15000.00	CY	50,850	1,526	7,856	60,232	4.02
GATX Dredging, Clamshell	15000.00	CY	50,850	1,526	7,856	60,232	4.02
GOLD BOND Dredging, Clamshell	5000.00	CY	16,950	509	2,619	20,077	4.02
LEVIN Dredging, Clamshell	11000.00	CY	37,290	1,119	5,761	44,170	4.02
TEXACO Dredging, Clamshell	5000.00	CY	16,950	509	2,619	20,077	4.02
TIME OIL Dredging, Clamshell	5000.00	CY	16,950	509	2,619	20,077	4.02
UNOCAL Dredging, Clamshell	3000.00	CY	10,170	305	1,571	12,046	4.02
TOTAL DREDGING & PARKING LOT DISPOSAL	96000.00	CY	325,440	9,763	50,280	385,484	4.02
DREDGING & MONTEZUMA DISPOSAL							
6C, 6D, 7							
Dredging, Clamshell	23000.00	CY	107,870	3,236	16,666	127,772	5.56
Tipping Fee	23000.00	CY	161,000	0	0	161,000	7.00
TOTAL 6C, 6D, 7	23000.00	CY	268,870	3,236	16,666	288,772	12.56

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** DETAIL SUMMARY OF FIRST COST **

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
MONTEZUMA/PARKING LOT ALT A1						
NON-FEDERAL COSTS						
120220-- Disposal Areas						
12022002 Site Work						
HANDLING AND HAULING						
Handling and Hauling	234000.00 CY	601,380	0	0	601,380	2.57
Rock Handling and Hauling	7000.00 CY	17,990	0	0	17,990	2.57
TOTAL HANDLING, HAULING AND DRYING	1.00 JOB	619,370	0	0	619,370	61937(
PARKING LOT SITE PREPARATION						
Berms	3500.00 CY	35,000	0	0	35,000	10.0(
Drainage	1.00 JOB	40,000	0	0	40,000	40000.0(
Access Road	1.00 JOB	102,000	0	0	102,000	102000.0(
Design, 7%	1.00 JOB	12,400	0	0	12,400	12400.0(
Contingencies, 20%	1.00 JOB	37,900	0	0	37,900	37900.0(
TOTAL PARKING LOT SITE PREPARATION	1.00 JOB	227,300	0	0	227,300	227300.0(
TOTAL NON-FEDERAL COSTS	1.00 JOB	2,665,980	12,999	66,946	2,745,925	274592
TOTAL MONTEZUMA/PARKING LOT ALT A1	1.00 JOB	35,328,637	366,866	1,899,280	37,594,783	3759478

BASIS OF COST
MONTEZUMA/PARKING LOT ALTERNATIVE A1

1. Project Description: The project consists of deepening Richmond Harbor to a project depth of -38 feet mean lower low water with a tolerance (overdepth) of 1 foot below project depth, except for areas of hard material where dredging will be -38 feet plus 1 foot overdepth and up to one foot of tolerance.

Approximately 1,492,000 cubic yards of soft material and 181,000 cubic yards of hard material would be dredged and deposited at the Montezuma upland disposal site.

Approximately 219,000 cubic yards of unsuitable soft material, 15,000 cubic yards of unsuitable hard material and approximately 7,000 cubic yards of underwater rock would be dredged and deposited at the local sponsor's Parking Lot upland disposal site.

2. Pricing is based on the January 1996 price level. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (Costs have been escalated from the previous January 1995 price level using an escalation factor of +3.0%). The estimate assumes that the Contractor will be working 24 hours a day, 7 days a week.

3. For disposal at the Montezuma disposal site, a tipping fee of $7.00 per cubic yard is assumed based on statements from the landowner and local sponsor. The tipping fee would cover site preparation, monitoring, and the unloading and spreading of material.

4. For disposal at the Parking Lot disposal site, initially the dredged material and the rock would be unloaded by the 2nd clamshell dredge at the drying area (approximately 8 acres) which is adjacent to the Parking Lot area. The material would then be loaded onto dump trucks and hauled to the Parking Lot area (approximately 46 acres) and spread and dried. The local sponsor has provided the costs for site preparation, handling, hauling, spreading and drying the materials.

5. Real estate costs were obtained from the Sacramento District, Real Estate Division.

6. The estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract by a prime contractor who will execute all the dredging, hauling and disposal operations unless noted otherwise.

7. Mobilization and demobilization for plant and equipment is based on the preparation, transfer, set-up and removal of plant and equipment required. It is assumed that moblilization and demoblization of all equipment can be completed in 14 days.

8. Dredging and disposal at the Montezuma disposal site would be performed by a 20 cy clamshell dredge, 6-4,000 c.y. bottom dump scows, 5-1,200 Hp hauling tugs, 1-850 Hp support tug, and other support equipment. The dredge/haul production rate is approximately 560 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

Dredging and disposal at the Parking Lot disposal site would be performed by a 20 cy clamshell dredge, 3-4,000 c.y. bottom dump scows, 2-1,200 Hp hauling tugs, 1-850 Hp support tug, other support equipment and a 2nd clamshell plant is used at the Parking Lot disposal site to unload to material. The dredge/haul production rate is approximately 620 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

For all dredging and disposal operations, the number of scows required is determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. Barges would be filled to 80% capacity and no overflow is allowed. Tugboat speed for the round trips is assumed to be 6 knots average speed.

9. Underwater rock would be excavated using the same clamshell plant and equipment, with a 9 cy bucket and a 2nd clamshell plant is used at the Parking Lot disposal area to unload to rock. Production rate would be approximately 70 cy/hr.

10. Hauling distance from the dredge site to the Montezuma disposal site is approximately 44 miles.

Hauling distance from the dredge site to the Parking Lot disposal site is approximately 1 mile.

11. Construction Time. The project can be completed in 7 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

MONTEZUMA/PARKING LOT ALTERNATIVE A1

Contingency Footnotes:

1/ Mobilization and demobilization costs are dependent on the location and availability of plant and equipment at the time the project is bid. A project of this magnitude will likely attract bidders from the East Coast. Availability of plant and equipment may be impacted by other jobs in progress in the local area such as annual maintenance dredging and the Oakland Harbor deepening project which will be in progress when this project is scheduled to commence.

2/ Clamshell dredging costs are dependent on the characteristics of the material to be dredged which affects production rates. Other unknown factors which will affect the dredging costs are marine traffic and weather conditions.

3/ Aids to navigation cost is dependent on the number of buoys and markers to be relocated and the number of safety markers to be installed during the project in accordance with marine regulations and as directed by the Coast Guard.

4/ Rock removal costs are dependent by the amount and condition of the rock. The information on the amount of rock is preliminary and no information is available on the effort necessary to break the rock.

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
BAY FARM ISLAND ALTERNATIVE B
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
12------	NAVIGATION, PORTS & HARBORS	$15,367,012	$2,136,386	$17,503,398	$525,102	$18,028,500
30------	PLANNING, ENGINEERING & DESIGN	$9,503,850	$0	$9,503,850	$285,116	$9,788,966
31------	CONSTRUCTION MANAGEMENT	$618,000	$0	$618,000	$18,540	$636,540
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$25,525,810	$2,141,928	$27,667,738	$830,032	$28,497,770
NON-FEDERAL COSTS						
12------	NAVIGATION, PORTS & HARBORS	$696,412	$68,762	$765,174	$22,955	$788,129
FEDERAL & NON-FEDERAL COSTS, TOTAL		$26,222,222	$2,210,690	$28,432,912	$852,987	$29,285,899

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** DETAIL SUMMARY OF FIRST COST **

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
BAY FARM ISLAND ALT B						
FEDERAL COSTS						
12------ NAVIGATION, PORTS & HARBORS						
1202---- HARBORS						
120201-- Mobilization & Demobilization, Contingency 25%, Reason 1/						
Mob & Demob, Clamshell	1.00 JOB	639,106	19,173	164,570	822,849	822848.98
120215-- Clamshell Dredging, Contingency 15%, Reason 2/						
SOFT DREDGING & BAY FARM DISP						
Dredging, Clamshell	1597000 CY	5,972,780	179,183	922,795	7,074,758	4.43
Tipping Charge	1597000 CY	3,194,000	0	0	3,194,000	2.00
TOTAL SOFT DREDGING & BAY FARM DISP	1597000 CY	9,166,780	179,183	922,795	10,268,758	6.43
HARD DREDGING & BAY FARM DISP						
Dredging, Clamshell	196000.00 CY	1,846,320	55,390	285,256	2,186,966	11.16
Tipping Charge	196000.00 CY	392,000	0	0	392,000	2.00
TOTAL HARD DREDGING & BAY FARM DISP	196000.00 CY	2,238,320	55,390	285,256	2,578,966	13.16
120215-- Clamshell Dredging, Contingency 25%, Reason 5/						
UNDERWATER ROCK EXCAVATION						
Rock Excavation & Disposal	7000.00 CY	135,030	4,051	34,770	173,851	24.84
Tipping Fee	7000.00 CY	14,000	0	0	14,000	2.00
TOTAL UNDERWATER ROCK EXCAVATION	7000.00 CY	149,030	4,051	34,770	187,851	26.84
120299-- Associated General Items, Contingency 25%, Reasons 3/, 4/						
AIDS TO NAVIGATION	1.00 JOB	100,000	3,000	25,750	128,750	128750.00
BAY FARM MONITORING	1.00 JOB	2,731,047	81,931	703,245	3,516,223	3516223
30------ PLANNING, ENGINEERING & DESIGN						
E&D						
E&D, Dredging	1.00 JOB	230,000	6,900	0	236,900	236900.00
E&D, Bay Farm Site	1.00 JOB	65,000	1,950	0	66,950	66950.00
E&D, Sunk	1.00 JOB	9,200,000	0	0	9,200,000	9200000
TOTAL E&D	1.00 JOB	9,495,000	8,850	0	9,503,850	9503850
31------ CONSTRUCTION MANAGEMENT (S&I)						
SIOH, Dredging	8.00 MO	600,000	18,000	0	618,000	77250.00
OPERATIONS & MAINTENANCE	11210.00 CY	35,872	1,076	5,542	42,490	3.79
TOTAL FEDERAL COSTS	1.00 JOB	25,155,155	370,655	2,141,928	27,667,737	27667737

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RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

BAY FARM ISLAND ALT B

NON-FEDERAL COSTS

12------ NAVIGATION, PORTS & HARBORS

1202---- HARBORS

120215-- Clamshell Dredging, Contingency 15%, Reason 2/
DREDGING & BAY FARM DISPOSAL

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
6C, 6D, 7							
Dredging, Clamshell	23000.00	CY	86,020	2,581	13,290	101,891	4.43
Tipping Fee	23000.00	CY	46,000	0	0	46,000	2.0
TOTAL 6C, 6D, 7	23000.00	CY	132,020	2,581	13,290	147,891	6.4
TERM 2							
Dredging, Clamshell	22000.00	CY	82,280	2,468	12,712	97,461	4.4
Tipping Fee	22000.00	CY	44,000	0	0	44,000	2.0
TOTAL TERM 2	22000.00	CY	126,280	2,468	12,712	141,461	6.4
TERM 3							
Dredging, Clamshell	15000.00	CY	56,100	1,683	8,667	66,450	4.4
Tipping Fee	15000.00	CY	30,000	0	0	30,000	2.0
TOTAL TERM 3	15000.00	CY	86,100	1,683	8,667	96,450	6.4
ARCO							
Dredging, Clamshell	15000.00	CY	56,100	1,683	8,667	66,450	4.4
Tipping Fee	15000.00	CY	30,000	0	0	30,000	2.0
TOTAL ARCO	15000.00	CY	86,100	1,683	8,667	96,450	6.4
GATX							
Dredging, Clamshell	15000.00	CY	56,100	1,683	8,667	66,450	4.
Tipping Fee	15000.00	CY	30,000	0	0	30,000	2.
TOTAL GATX	15000.00	CY	86,100	1,683	8,667	96,450	6.
GOLD BOND							
Dredging, Clamshell	5000.00	CY	18,700	561	2,889	22,150	4.
Tipping Fee	5000.00	CY	10,000	0	0	10,000	2.
TOTAL GOLD BOND	5000.00	CY	28,700	561	2,889	32,150	6.
LEVIN							
Dredging, Clamshell	11000.00	CY	41,140	1,234	6,356	48,730	4.
Tipping Fee	11000.00	CY	22,000	0	0	22,000	2.
TOTAL LEVIN	11000.00	CY	63,140	1,234	6,356	70,730	6

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U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
BAY FARM ISLAND ALT B							
NON-FEDERAL COSTS							
TEXACO							
Dredging, Clamshell	5000.00	CY	18,700	561	2,889	22,150	4.43
Tipping Fee	5000.00	CY	10,000	0	0	10,000	2.00
TOTAL TEXACO	5000.00	CY	28,700	561	2,889	32,150	6.43
TIME OIL							
Dredging, Clamshell	5000.00	CY	18,700	561	2,889	22,150	4.43
Tipping Fee	5000.00	CY	10,000	0	0	10,000	2.00
TOTAL TIME OIL	5000.00	CY	28,700	561	2,889	32,150	6.43
UNOCAL							
Dredging, Clamshell	3000.00	CY	11,200	337	1,733	13,290	4.43
Tipping Fee	3000.00	CY	6,000	0	0	6,000	2.00
TOTAL UNOCAL	3000.00	CY	17,220	337	1,733	19,290	6.43
TOTAL DREDGING & BAY FARM DISPOSAL	119000.00	CY	683,060	13,352	68,762	765,174	6.43
TOTAL NON-FEDERAL COSTS	1.00	JOB	683,060	13,352	68,762	765,174	765173.57
TOTAL BAY FARM ISLAND ALT B	1.00	JOB	25,838,215	384,006	2,210,690	28,432,911	28432911

BASIS OF COST
BAY FARM ISLAND ALTERNATIVE B

1. Project Description: The project consists of deepening Richmond Harbor to a project depth of -38 feet mean lower low water with a tolerance (overdepth) of 1 foot below project depth, except for areas of hard material where dredging will be -38 feet plus 1 foot overdepth and up to one foot of tolerance.

Approximately 1,716,000 cubic yards of soft material, 196,000 cubic yards of hard material and approximately 7,000 cubic yards of rock would be dredged and deposited at the Bay Farm Island disposal area.

2. Pricing is based on the January 1996 price level. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (Costs have been escalated from the previous January 1995 price level using an escalation factor of +3.0%). The estimate assumes that the Contractor will be working 24 hours a day, 7 days a week. A tipping fee of $2.00 per cubic yard is assumed.

3. The estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract by a prime contractor who will execute all the dredging, hauling and disposal operations unless noted otherwise.

4. Mobilization and demobilization for plant and equipment is based on the preparation, transfer, set-up and removal of plant and equipment required. It is assumed that moblilization and demoblization of all equipment can be completed in 14 days.

5. Dredging is assumed to be performed by a 20 cy clamshell dredge, 4-3,000 c.y. bottom dump scows, 3-1,200 Hp hauling tugs, 1-850 Hp support tug, and other support equipment. The number of scows required is determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. The dredge/haul production rate is approximately 530 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month). Scows are assumed to be filled to 80% capacity and no overflow is allowed. Tugboat speed for the round trip is assumed to be 6 knots average speed.

6. Underwater rock would be excavated using the same clamshell plant and equipment with a 9 cy bucket. Production rate would be approximately 70 cy/hr.

7. Hauling distance to the dredge site to the Bay Farm Island disposal area is approximately 20 miles.

8. At the Bay Farm disposal area, material would be unloaded by bottom dumping from the dump scows. A layer of suitable material would be deposited first to line the disposal site bottom, next the unsuitable material would be deposited and then the remaining suitable material would deposited on top as cover. The cost for this operation is included in the cost estimate.

9. Construction Time. The project can be completed in 8 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

BAY FARM ISLAND ALTERNATIVE B

Contingency Footnotes:

1/ Mobilization and demobilization costs are dependent on the location and availability of plant and equipment at the time the project is bid. A project of this magnitude will likely attract bidders from the East Coast. Availability of plant and equipment may be impacted by other jobs in progress in the local area such as annual maintenance dredging and the Oakland Harbor deepening project which will be in progress when this project is scheduled to commence.

2/ Clamshell dredging costs are dependent on the characteristics of the material to be dredged which affects production rates. Additional control may be required to ensure that unsuitable material is capped by suitable material in the disposal process. Other unknown factors which will affect the dredging costs are marine traffic and weather conditions.

3/ Aids to navigation cost is dependent on the number of buoys and markers to be relocated and the number of safety markers to be installed during the project in accordance with marine regulations and as directed by the Coast Guard.

4/ For Bay Farm monitoring, the cost is based on a quote from a private firm for such monitoring if the Oakland Harbor deepening project was to have used the disposal site and is subject to change based on the actual monitoring requirements when the project takes place.

5/ Rock removal costs are dependent by the amount and condition of the rock. The information on the amount of rock is preliminary and no information is available on the effort necessary to break the rock.

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
OCEAN/GRAVING DOCKS ALTERNATIVE C
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
01------	LANDS & DAMAGES	$60,800	$4,200	$65,000	$1,560 *	$66,560
12------	NAVIGATION, PORTS & HARBORS	$17,699,246	$2,871,700	$20,570,946	$617,128	$21,188,074
30------	PLANNING, ENGINEERING & DESIGN	$9,503,850	$0	$9,503,850	$285,116	$9,788,966
31------	CONSTRUCTION MANAGEMENT	$695,250	$0	$695,250	$20,858	$716,108
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$27,996,094	$2,881,442	$30,877,536	$925,936	$31,803,472
NON-FEDERAL COSTS						
01------	LANDS & DAMAGES	$1,743,000	$602,000	$2,345,000	$56,280 *	$2,401,280
12------	NAVIGATION, PORTS & HARBORS	$10,495,929	$479,694	$10,975,623	$329,269	$11,304,892
NON-FEDERAL COSTS, TOTAL		$12,238,929	$1,081,694	$13,320,623	$385,549	$13,706,172
FEDERAL & NON-FEDERAL COSTS, TOTAL		$40,235,023	$3,963,136	$44,198,159	$1,311,485	$45,509,644

*Real Estate costs are escalated to the Certification date for LERRDS, 7/96.

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** DETAIL SUMMARY OF FIRST COST **

		QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
	OCEAN/GRAVING DOCKS ALT C						
	FEDERAL COSTS						
01------	LANDS & DAMAGES, GRAVING DOCKS						
01------	SUNK COSTS - Planning	1.00 JOB	2,800	0	0	2,800	2800.00
0121----	FEATURE DESIGN MEMORANDUM (FDM)						
01210301	Real Estate Supplement/Plan	1.00 JOB	20,000	0	1,500	21,500	21500.00
01210302	Gross Appraisal/Report	1.00 JOB	12,000	0	800	12,800	12800.00
01210303	Prelim Real Estate Acquistn Maps	1.00 JOB	8,000	0	600	8,600	8600.00
01210304	Physical Takngs Analysis Reports	1.00 JOB	2,000	0	100	2,100	2100.00
01210307	All Other Real Estate Analy/Docs	1.00 JOB	3,000	0	200	3,200	3200.00
0123----	CONSTRUCTION CONTRACT DOCUMENTS						
01230302	Real Estate Acquisition Document	1.00 JOB	4,000	0	300	4,300	4300.00
01230317	Real Estate LERRD Crediting Docs	1.00 JOB	8,000	0	600	8,600	8600.00
01230318	Real Estate All Other Documents	1.00 JOB	1,000	0	100	1,100	1100.00
01------	TOTAL LANDS & DAMAGES, GRAVING DOCKS	1.00 JOB	60,800	0	4,200	65,000	65000.00
12------	NAVIGATION, PORTS & HARBORS						
1202----	HARBORS						
120201--	Mobilization & Demobilization, Contingency 25%, Reason 1/						
	Mob & Demob, Clamshell	1.00 JOB	956,845	28,705	246,388	1,231,938	1231938
120215--	Clamshell Dredging, Contingency 15%, Reason 2/						
	SOFT DREDGING & OCEAN DISPOSAL Dredging, Clamshell	1496000 CY	12,282,160	368,465	1,897,594	14,548,219	9.72
	SOFT DREDGING/GRAVING DOCKS DISP Dredging, Clamshell	123000.00 CY	353,010	10,590	54,540	418,140	3.40
	HARD DREDGING & OCEAN DISPOSAL Dredging, Clamshell	181000.00 CY	2,295,080	68,852	354,590	2,718,522	15.02
	HARD DREDGING/GRAVING DOCKS DISP Dredging, Clamshell	15000.00 CY	148,500	4,455	22,943	175,898	11.73
120215--	Clamshell Dredging, Contingency 25%, Reason 5/						
	Rock Excavation & Disposal	7000.00 CY	182,070	5,462	46,883	234,415	33.49
120299--	Associated General Items, Contingency 25%, Reasons 3/, 4/						
	AIDS TO NAVIGATION	1.00 JOB	100,000	3,000	25,750	128,750	128750.00
	OCEAN MONITORING	1.00 JOB	892,051	0	223,013	1,115,063	1115063

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Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/GRAVING DOCKS ALT C							
FEDERAL COSTS							
30------ PLANNING, ENGINEERING & DESIGN							
E&D							
E&D, Dredging	1.00	JOB	230,000	6,900	0	236,900	236900.00
E&D, Ocean Site	1.00	JOB	10,000	300	0	10,300	10300.00
E&D, Graving Docks	1.00	JOB	55,000	1,650	0	56,650	56650.00
E&D, Sunk	1.00	JOB	9,200,000	0	0	9,200,000	9200000
TOTAL E&D	1.00	JOB	9,495,000	8,850	0	9,503,850	9503850
31------ CONSTRUCTION MANAGEMENT (S&I)							
SIOH, Dredging	9.00	MO	675,000	20,250	0	695,250	77250.00
OPERATIONS & MAINTENANCE	11210.00	CY	35,872	1,076	5,542	42,490	3.79
TOTAL FEDERAL COSTS	1.00	JOB	27,476,388	519,706	2,881,442	30,877,536	30877536

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** DETAIL SUMMARY OF FIRST COST **

		QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
	OCEAN/GRAVING DOCKS ALT C							
	NON-FEDERAL COSTS							
01------	LANDS & DAMAGES, GRAVING DOCKS							
0123----	CONSTRUCTION CONTRACT DOCUMENTS							
01230302	Real Estate Acquisition Document	1.00	JOB	5,000	0	800	5,800	5800.00
01230305	Real Estate Appraisal Documents	1.00	JOB	8,000	0	1,200	9,200	9200.00
01230316	Real Estate Receipt Documents	1.00	JOB	1,730,000	0	600,000	2,330,000	2330000
01------	TOTAL LANDS & DAMAGES, GRAVING DOCKS	1.00	JOB	1,743,000	0	602,000	2,345,000	2345000
12------	NAVIGATION, PORTS & HARBORS							
1202----	HARBORS							
120215--	Clamshell Dredging, Contingency 15%, Reason 2/							
	DREDGING & OCEAN DISPOSAL							
	6C, 6D, 7 Dredging, Clamshell	23000.00	CY	188,830	5,665	29,174	223,669	9.72
	DREDGING & GRAVING DOCKS DISPOSE							
	TERM 2 Dredging, Clamshell	22000.00	CY	63,140	1,894	9,755	74,789	3.40
	TERM 3 Dredging, Clamshell	15000.00	CY	43,050	1,292	6,651	50,993	3.40
	ARCO Dredging, Clamshell	15000.00	CY	43,050	1,292	6,651	50,993	3.40
	GATX Dredging, Clamshell	15000.00	CY	43,050	1,292	6,651	50,993	3.40
	GOLD BOND Dredging, Clamshell	5000.00	CY	14,350	431	2,217	16,998	3.40
	LEVIN Dredging, Clamshell	11000.00	CY	31,570	947	4,878	37,395	3.40
	TEXACO Dredging, Clamshell	5000.00	CY	14,350	431	2,217	16,998	3.40
	TIME OIL Dredging, Clamshell	5000.00	CY	14,350	431	2,217	16,998	3.40
	UNOCAL Dredging, Clamshell	3000.00	CY	8,610	258	1,330	10,199	3.40
	TOTAL DREDGING & GRAVING DOCKS DISPOSE	96000.00	CY	275,520	8,266	42,568	326,353	3.40

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	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/GRAVING DOCKS ALT C							
NON-FEDERAL COSTS							
120220-- Disposal Areas							
12022002 Site Work							
GRAVING DOCKS SITE PREPARATION							
BASIN 1	1.00	JOB	1,550,000	0	0	1,550,000	1550000
BASIN 5	1.00	JOB	1,550,000	0	0	1,550,000	1550000
BASINS 2,3	1.00	JOB	2,550,000	0	0	2,550,000	2550000
NEW WHARF AT BASIN 5	1.00	JOB	1,290,000	0	0	1,290,000	1290000
EXISTING WHARF AT BERTH 6A	1.00	JOB	1,130,000	0	0	1,130,000	1130000
TOTAL GRAVING DOCKS SITE PREPARATION	1.00	JOB	8,070,000	0	0	8,070,000	8070000
GRAVING DOCKS EXCESS MATERIAL							
OFF-LOAD, MUD AND ROCK							
Off-Load, Mud and Rock	64000.00	CY	64,000	0	0	64,000	1.0
Contingency, 20%	1.00	JOB	12,800	0	0	12,800	12800.0
Design, 7%	1.00	JOB	5,376	0	0	5,376	5376.0
Construction Support, 5%	1.00	JOB	3,840	0	0	3,840	3840.0
TOTAL OFF-LOAD, MUD AND ROCK	64000.00	CY	86,016	0	0	86,016	1.3
DECANT/DRY, MUD							
Decant/Dry, Mud	57000.00	CY	171,000	0	0	171,000	3.0
Contingency, 20%	1.00	JOB	34,200	0	0	34,200	34200.0
Design, 7%	1.00	JOB	14,364	0	0	14,364	14364.0
Construction Support, 5%	1.00	JOB	10,260	0	0	10,260	10260.0
TOTAL DECANT/DRY, MUD	57000.00	CY	229,824	0	0	229,824	4.0
TRUCK HAUL & MATERIAL TESTING, Contingency 25%, Reason 6/							
Truck Haul to Vasco Rd. Landfill	64000.00	CY	1,572,546	47,176	404,931	2,024,653	31.
Test Mat. for Vasco Rd. Landfill	57000.00	CY	11,734	352	3,021	15,107	0.
TOTAL GRAVING DOCKS EXCESS MATERIAL	1.00	JOB	1,900,120	47,528	407,952	2,355,600	23556
TOTAL NON-FEDERAL COSTS	1.00	JOB	12,177,470	61,459	1,081,694	13,320,623	133206
TOTAL OCEAN/GRAVING DOCKS ALT C	1.00	JOB	39,653,857	581,165	3,963,136	44,198,159	441981

BASIS OF COST
OCEAN/GRAVING DOCKS ALTERNATIVE C

1. Project Description: The project consists of deepening Richmond Harbor to a project depth of -38 feet mean lower low water with a tolerance (overdepth) of 1 foot below project depth, except for areas of hard material where dredging will be -38 feet plus 1 foot overdepth and up to one foot of tolerance.

Approximately 1,496,000 cubic yards of soft material and 181,000 cubic yards of hard material will be deposited at the EPA approved Ocean disposal site.

Approximately 219,000 cubic yards of unsuitable soft material, 15,000 cubic yards of unsuitable hard material and 7,000 cubic yards of rock would be deposited at the Graving Docks disposal site.

2. Pricing is based on the January 1996 price level. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (Costs have been escalated from the previous January 1995 price level using an escalation factor of +3.0%). The estimate assumes that the Contractor will be working 24 hours a day, 7 days a week.

3. Real estate costs for the Graving Docks disposal site are provided by Sacramento District real estate office. Site preparation costs for the Graving Docks are provided by the local sponsor and include site preparation, unloading the dredged material, processing, drying, hauling and placing the material from the drying area into the Graving Docks, engineering and design, construction management and contingencies.

4. The estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract by a prime contractor who will execute all the dredging, hauling and disposal operations unless noted otherwise.

5. Mobilization and demobilization for plant and equipment is based on the preparation, transfer, set-up and removal of plant and equipment required. It is assumed that moblilization and demoblization of all equipment can be completed in 14 days.

6. Dredging would be performed by a 20 cy clamshell dredge.

The Ocean disposal work would use 6-4,000 c.y. bottom dump scows, 5-2,300 Hp hauling tugs, 1-850 Hp support tug, and other support equipment. The dredge/haul production rate is approximately 360 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

The Graving Docks disposal work would use 3-4,000 cy barges, 2-2,300 Hp hauling tugs, 1-850 Hp support tug, and other support equipment. The dredge/haul production rate is approximately 620 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

The number of scows required is determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. Barges would be filled to 80% capacity and no overflow is allowed. Tugboat speed for the round trips is assumed to be 6 knots average speed.

7. Underwater rock would be excavated using the same clamshell plant and equipment with a 9 cy bucket. Production rate would be approximately 70 cy/hr.

8. Hauling distance from the dredge site to the Ocean disposal site is approximately 72 miles.

Hauling distance from the dredge site to the Graving Docks disposal site is approximately 1 mile.

9. At the Ocean disposal site, dredged material would be unloaded by bottom dumping from the dump scows.

At the Graving Docks disposal site, the dredged material and rock would be unloaded by a clamshell. The capacity of the Graving Docks is only 178,000 cubic yards. Therefore the excess material, 57,000 cubic yards (235,000 - 178,000) and 7,000 cubic yards of rock would be loaded and hauled to a landfill which can accomodate unsuitable material. The cost of these operations at the Graving Docks site is included in the estimate as a Non-Federal cost.

10. Construction Time. The project can be completed in 9 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

OCEAN/GRAVING DOCKS ALTERNATIVE C

Contingency Footnotes:

1/ Mobilization and demobilization costs are dependent on the location and availability of plant and equipment at the time the project is bid. A project of this magnitude will likely attract bidders from the East Coast. Availability of plant and equipment may be impacted by other jobs in progress in the local area such as annual maintenance dredging and the Oakland Harbor deepening project which will be in progress when this project is scheduled to commence.

2/ Clamshell dredging costs are dependent on the characteristics of the material to be dredged which affects production rates. Other unknown factors which will affect the dredging costs are marine traffic and weather conditions, especially for ocean disposal.

3/ Aids to navigation cost is dependent on the number of buoys and markers to be relocated and the number of safety markers to be installed during the project in accordance with marine regulations and as directed by the Coast Guard.

4/ For Ocean disposal monitoring, the cost is based on a quote from a private firm for ocean site monitoring for the Oakland Harbor deepening project and is subject to change based on the extent of actual monitoring requirements when the project is awarded.

5/ Rock removal costs are dependent by the amount and condition of the rock. The information on the amount of rock is preliminary and no information is available on the effort necessary to break the rock.

6/ Hauling costs are dependent on the distance to the landfill, amount of tipping fee and condition of haul routes. Testing costs are dependent on material characteristics of the dredged material, material acceptance criteria and moisture content. No final landfill site has been selected.

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
OCEAN\MONTEZUMA ALTERNATIVE C1
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
12------	NAVIGATION, PORTS & HARBORS	$20,806,529	$2,702,002	$23,508,531	$705,256	$24,213,787
30------	PLANNING, ENGINEERING & DESIGN	$9,457,500	$0	$9,457,500	$283,725	$9,741,225
31------	CONSTRUCTION MANAGEMENT	$695,250	$0	$695,250	$20,858	$716,108
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$30,996,227	$2,707,544	$33,703,771	$1,011,113	$34,714,884
NON-FEDERAL COSTS						
12------	NAVIGATION, PORTS & HARBORS	$1,388,581	$107,487	$1,496,068	$44,882	$1,540,950
FEDERAL & NON-FEDERAL COSTS, TOTAL		$32,384,808	$2,815,031	$35,199,839	$1,055,995	$36,255,834

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** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/MONTEZUMA ALT C1							
FEDERAL COSTS							
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120201-- Mobilization & Demobilization, Contingency 25%, Reason 1/							
Mob & Demob, Clamshell	1.00	JOB	956,845	28,705	246,388	1,231,938	1231938
120215-- Clamshell Dredging, Contingency 15%, Reason 2/							
SOFT DREDGING & MONTEZUMA DISP							
Dredging, Clamshell	591000.00	CY	3,120,480	93,614	482,114	3,696,209	6.25
Tipping Fee	591000.00	CY	4,137,000	0	0	4,137,000	7.00
TOTAL SOFT DREDGING & MONTEZUMA DISP	591000.00	CY	7,257,480	93,614	482,114	7,833,209	13.25
SOFT DREDGING & OCEAN DISPOSAL							
Dredging, Clamshell	1073000	CY	8,809,330	264,280	1,361,041	10,434,651	9.72
HARD DREDGING & MONTEZUMA DISP							
Dredging, Clamshell	15000.00	CY	186,600	5,598	28,830	221,028	14.74
Tipping Fee	15000.00	CY	105,000	0	0	105,000	7.00
TOTAL HARD DREDGING & MONTEZUMA DISP	15000.00	CY	291,600	5,598	28,830	326,028	21.74
HARD DREDGING & OCEAN DISPOSAL							
Dredging, Clamshell	181000.00	CY	2,295,080	68,852	354,590	2,718,522	15.02
120215-- Clamshell Dredging, Contingency 25%, Reason 5/							
UNDERWATER ROCK EXCAVATION							
Rock Excavation & Disposal	7000.00	CY	258,370	7,751	66,530	332,651	47.52
Tipping Fee	7000.00	CY	49,000	0	0	49,000	7.00
TOTAL UNDERWATER ROCK EXCAVATION	7000.00	CY	307,370	7,751	66,530	381,651	54.52
120299-- Associated General Items, Contingency 25%, Reasons 3/, 4/							
AIDS TO NAVIGATION	1.00	JOB	100,000	3,000	25,750	128,750	128750.00
OCEAN MONITORING	1.00	JOB	892,051	0	223,013	1,115,063	1115063
30------ PLANNING, ENGINEERING & DESIGN							
E&D							
E&D, Dredging	1.00	JOB	240,000	7,200	0	247,200	247200.00
E&D, Ocean Site	1.00	JOB	10,000	300	0	10,300	10300.00
E&D, Sunk	1.00	JOB	9,200,000	0	0	9,200,000	9200000
TOTAL E&D	1.00	JOB	9,450,000	7,500	0	9,457,500	9457500

U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/MONTEZUMA ALT C1						
FEDERAL COSTS						
31------ CONSTRUCTION MANAGEMENT (S&I)						
SIOH, Dredging	9.00 MO	675,000	20,250	0	695,250	77250.00
OPERATIONS & MAINTENANCE	11210.00 CY	35,872	1,076	5,542	42,490	3.79
TOTAL FEDERAL COSTS	1.00 JOB	30,512,348	483,879	2,707,544	33,703,770	33703770

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** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/MONTEZUMA ALT C1							
NON-FEDERAL COSTS							
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120215-- Clamshell Dredging, Contingency 15%, Reason 2/ DREDGING & MONTEZUMA DISPOSAL							
TERM 2							
Dredging, Clamshell	22000.00	CY	116,160	3,485	17,947	137,592	6.25
Tipping Fee	22000.00	CY	154,000	0	0	154,000	7.00
TOTAL TERM 2	22000.00	CY	270,160	3,485	17,947	291,592	13.25
TERM 3							
Dredging, Clamshell	15000.00	CY	79,200	2,376	12,236	93,812	6.25
Tipping Fee	15000.00	CY	105,000	0	0	105,000	7.00
TOTAL TERM 3	15000.00	CY	184,200	2,376	12,236	198,812	13.25
ARCO							
Dredging, Clamshell	15000.00	CY	79,200	2,376	12,236	93,812	6.25
Tipping Fee	15000.00	CY	105,000	0	0	105,000	7.00
TOTAL ARCO	15000.00	CY	184,200	2,376	12,236	198,812	13.25
GATX							
Dredging, Clamshell	15000.00	CY	79,200	2,376	12,236	93,812	6.25
Tipping Fee	15000.00	CY	105,000	0	0	105,000	7.00
TOTAL GATX	15000.00	CY	184,200	2,376	12,236	198,812	13.25
GOLD BOND							
Dredging, Clamshell	5000.00	CY	26,400	792	4,079	31,271	6.25
Tipping Fee	5000.00	CY	35,000	0	0	35,000	7.00
TOTAL GOLD BOND	5000.00	CY	61,400	792	4,079	66,271	13.25
LEVIN							
Dredging, Clamshell	11000.00	CY	58,080	1,742	8,973	68,796	6.25
Tipping Fee	11000.00	CY	77,000	0	0	77,000	7.00
TOTAL LEVIN	11000.00	CY	135,080	1,742	8,973	145,796	13.25
TEXACO							
Dredging, Clamshell	5000.00	CY	26,400	792	4,079	31,271	6.25
Tipping Fee	5000.00	CY	35,000	0	0	35,000	7.00
TOTAL TEXACO	5000.00	CY	61,400	792	4,079	66,271	13.25

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Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/MONTEZUMA ALT C1							
NON-FEDERAL COSTS							
TIME OIL							
Dredging, Clamshell	5000.00	CY	26,400	792	4,079	31,271	6.25
Tipping Fee	5000.00	CY	35,000	0	0	35,000	7.00
TOTAL TIME OIL	5000.00	CY	61,400	792	4,079	66,271	13.25
UNOCAL							
Dredging, Clamshell	3000.00	CY	15,840	475	2,447	18,762	6.25
Tipping Fee	3000.00	CY	21,000	0	0	21,000	7.00
TOTAL UNOCAL	3000.00	CY	36,840	475	2,447	39,762	13.25
TOTAL DREDGING & MONTEZUMA DISPOSAL	96000.00	CY	1,178,880	15,206	78,313	1,272,399	13.25
DREDGING & OCEAN DISPOSAL							
6C, 6D, 7							
Dredging, Clamshell	23000.00	CY	188,830	5,665	29,174	223,669	9.72
TOTAL NON-FEDERAL COSTS	1.00	JOB	1,367,710	20,871	107,487	1,496,068	1496068
TOTAL OCEAN/MONTEZUMA ALT C1	1.00	JOB	31,880,058	504,750	2,815,031	35,199,839	35199839

BASIS OF COST
OCEAN/MONTEZUMA ALTERNATIVE C1

1. Project Description: The project consists of deepening Richmond Harbor to a project depth of -38 feet mean lower low water with a tolerance (overdepth) of 1 foot below project depth, except for areas of hard material where dredging will be -38 feet plus 1 foot overdepth and up to one foot of tolerance.

Approximately 1,028,000 cubic yards of soft material and 181,000 cubic yards of hard material would be dredged and deposited at the EPA approved Ocean disposal site.

Approximately 687,000 cubic yards of soft material, 15,000 cubic yards of hard material and 7,000 cubic yards of underwater rock would be dredged and deposited at the Montezuma upland disposal site.

2. Pricing is based on the January 1996 price level. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (Costs have been escalated from the previous January 1995 price level using an escalation factor of +3.0%). The estimate assumes that the Contractor will be working 24 hours a day, 7 days a week.

3. For disposal at the Montezuma disposal site, a tipping fee of $7.00 per cubic yard is assumed based on statements from the landowner and local sponsor. The tipping fee would cover site preparation, monitoring, and the unloading and spreading of material and rock.

4. The estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract by a prime contractor who will execute all the dredging, hauling and disposal operations unless noted otherwise.

5. Mobilization and demobilization for plant and equipment is based on the preparation, transfer, set-up and removal of plant and equipment required. It is assumed that moblilization and demoblization of all equipment can be completed in 14 days.

6. Dredging and disposal at the Ocean disposal site would be performed by a 20 cy clamshell dredge, 6-4,000 c.y. bottom dump scows, 5-2,300 Hp hauling tugs, 1-850 Hp support tug, other support equipment. The dredge/haul production rate is approximately 360 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

Dredging and disposal at the Montezuma disposal site would be performed by a 20 cy clamshell dredge, 6-4,000 c.y. bottom dump scows, 5-2,300 Hp hauling tugs, 1-850 Hp support tug, and other support equipment. The dredge/haul production rate is approximately 560 cy/hr for soft material and 110 cy/hr for hard material (Based on working 730 hours/month).

For all dredging and disposal operations, the number of scows required is determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. Barges would be filled to 80% capacity and no overflow is allowed. Tugboat speed for the round trips is assumed to be 6 knots average speed.

7. Underwater rock would be excavated using the same clamshell plant and equipment with a 9 cy bucket. Production rate would be approximately 70 cy/hr.

8. Hauling distance from the dredge site to the Ocean disposal site is approximately 72 miles.

Hauling distance from the dredge site to the Montezuma disposal site is approximately 44 miles.

9. Construction Time. The project can be completed in 9 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

OCEAN/MONTEZUMA ALTERNATIVE C1

Contingency Footnotes:

1/ Mobilization and demobilization costs are dependent on the location and availability of plant and equipment at the time the project is bid. A project of this magnitude will likely attract bidders from the East Coast. Availability of plant and equipment may be impacted by other jobs in progress in the local area such as annual maintenance dredging and the Oakland Harbor deepening project which will be in progress when this project is scheduled to commence.

2/ Clamshell dredging costs are dependent on the characteristics of the material to be dredged which affects production rates. Other unknown factors which will affect the dredging costs are marine traffic and weather conditions, especially for ocean disposal.

3/ Aids to navigation cost is dependent on the number of buoys and markers to be relocated and the number of safety markers to be installed during the project in accordance with marine regulations and as directed by the Coast Guard.

4/ For Ocean disposal monitoring, the cost is based on a quote from a private firm for ocean site monitoring for the Oakland Harbor deepening project and is subject to change based on the extent of actual monitoring requirements when the project is awarded.

5/ Rock removal costs are dependent by the amount and condition of the rock. The information on the amount of rock is preliminary and no information is available on the effort necessary to break the rock.

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
OCEAN/PARKING LOT ALTERNATIVE C2
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
01------	LANDS & DAMAGES	$89,100	$0	$89,100	$2,138 *	$91,238
12------	NAVIGATION, PORTS & HARBORS	$17,842,246	$2,912,663	$20,754,909	$622,647	$21,377,556
30------	PLANNING, ENGINEERING & DESIGN	$9,503,850	$0	$9,503,850	$285,116	$9,788,966
31------	CONSTRUCTION MANAGEMENT	$695,250	$0	$695,250	$20,858	$716,108
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$28,167,394	$2,918,205	$31,085,599	$932,033	$32,017,632
NON-FEDERAL COSTS						
01------	LANDS & DAMAGES	$1,225,000	$0	$1,225,000	$29,400 *	$1,254,400
12------	NAVIGATION, PORTS & HARBORS	$1,397,133	$82,569	$1,479,702	$44,391	$1,524,093
NON-FEDERAL COSTS, TOTAL		$2,622,133	$82,569	$2,704,702	$73,791	$2,778,493
FEDERAL & NON-FEDERAL COSTS, TOTAL		$30,789,527	$3,000,774	$33,790,301	$1,005,824	$34,796,125

*Real Estate costs are escalated to the Certification date for LERRDS, 7/96.

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Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COS
OCEAN/PARKING LOT ALT C2							
FEDERAL COSTS							
01------ LANDS AND DAMAGES, PARKING LOT							
Federal Review	1.00	JOB	89,100	0	0	89,100	89100.0(
12------ NAVIGATION, PORTS & HARBORS							
1202---- HARBORS							
120201-- Mobilization & Demobilization, Contingency 25%, Reason 1/							
Mob & Demob, Clamshell	1.00	JOB	1,100,000	33,000	283,250	1,416,250	141625(
120215-- Clamshell Dredging, Contingency 15%, Reason 2/							
SOFT DREDGING & OCEAN DISPOSAL							
Dredging, Clamshell	1473000	CY	12,093,330	362,800	1,868,420	14,324,550	9.7
SOFT DREDGING & PARKING LOT DISP							
Dredging, Clamshell	123000.00	CY	442,800	13,284	68,413	524,497	4.2
HARD DREDGING & OCEAN DISPOSAL							
Dredging, Clamshell	181000.00	CY	2,295,080	68,852	354,590	2,718,522	15.0
HARD DREDGING & PARKING LOT DISP							
Dredging, Clamshell	15000.00	CY	196,950	5,909	30,429	233,287	15.55
120215-- Clamshell Dredging, Contingency 25%, Reason 5/							
Rock Excavation & Disposal	7000.00	CY	228,340	6,850	58,798	293,988	42.0(
120299-- Associated General Items, Contingency 25%, Reasons 3/, 4/							
AIDS TO NAVIGATION	1.00	JOB	100,000	3,000	25,750	128,750	128750.0(
OCEAN MONITORING	1.00	JOB	892,051	0	223,013	1,115,063	111506
30------ PLANNING, ENGINEERING & DESIGN							
E&D							
E&D, Dredging	1.00	JOB	230,000	6,900	0	236,900	236900.0(
E&D, Ocean Site	1.00	JOB	10,000	300	0	10,300	10300.0(
E&D, Parking Lot	1.00	JOB	55,000	1,650	0	56,650	56650.0(
E&D, Sunk	1.00	JOB	9,200,000	0	0	9,200,000	920000(
TOTAL E&D	1.00	JOB	9,495,000	8,850	0	9,503,850	950385(
31------ CONSTRUCTION MANAGEMENT (S&I)							
SIOH, Dredging	9.00	MO	675,000	20,250	0	695,250	77250.0(
OPERATIONS & MAINTENANCE	11210.00	CY	35,872	1,076	5,542	42,490	3.7
TOTAL FEDERAL COSTS	1.00	JOB	27,643,523	523,871	2,918,203	31,085,597	3108559

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U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COS
OCEAN/PARKING LOT ALT C2						
NON-FEDERAL COSTS						
01------ LANDS AND DAMAGES, PARKING LOT						
Non-Federal Review	1.00 JOB	15,000	0	0	15,000	1500
Lands (LERRDS)	1.00 JOB	1,210,000	0	0	1,210,000	121000
01------ TOTAL LANDS AND DAMAGES, PARKING LOT	1.00 JOB	1,225,000	0	0	1,225,000	122500
12------ NAVIGATION, PORTS & HARBORS						
1202---- HARBORS						
120215-- Clamshell Dredging, Contingency 15%, Reason 2/						
DREDGING & OCEAN DISPOSAL						
6C, 6D, 7						
Dredging, Clamshell	23000.00 CY	188,830	5,665	29,174	223,669	9.7
DREDGING & PARKING LOT DISPOSAL						
TERM 2						
Dredging, Clamshell	22000.00 CY	79,200	2,376	12,236	93,812	4.2
TERM 3						
Dredging, Clamshell	15000.00 CY	54,000	1,620	8,343	63,963	4.2
ARCO						
Dredging, Clamshell	15000.00 CY	54,000	1,620	8,343	63,963	4.2
GATX						
Dredging, Clamshell	15000.00 CY	54,000	1,620	8,343	63,963	4.2
GOLD BOND						
Dredging, Clamshell	5000.00 CY	18,000	540	2,781	21,321	4.2
LEVIN						
Dredging, Clamshell	11000.00 CY	39,600	1,188	6,118	46,906	4.2
TEXACO						
Dredging, Clamshell	5000.00 CY	18,000	540	2,781	21,321	4.2
TIME OIL						
Dredging, Clamshell	5000.00 CY	18,000	540	2,781	21,321	4.2
UNOCAL						
Dredging, Clamshell	3000.00 CY	10,800	324	1,669	12,793	4.2
TOTAL DREDGING & PARKING LOT DISPOSAL	96000.00 CY	345,600	10,368	53,395	409,363	4.2

U.S. Army Corps of Engineers
RICHMOND HARBOR, -38' DEEPENING, GDM Alternatives
Preliminary Cost Estimates With Profit
** DETAIL SUMMARY OF FIRST COST **

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
OCEAN/PARKING LOT ALT C2							
NON-FEDERAL COSTS							
120220-- Disposal Areas							
12022002 Site Work							
HANDLING, HAULING AND DRYING							
Handling and Hauling	234000.00	CY	601,380	0	0	601,380	2.57
Rock Handling and Hauling	7000.00	CY	17,990	0	0	17,990	2.57
TOTAL HANDLING, HAULING AND DRYING	1.00	JOB	619,370	0	0	619,370	619370
PARKING LOT SITE PREPARATION							
Berms	3500.00	CY	35,000	0	0	35,000	10.00
Drainage	1.00	JOB	40,000	0	0	40,000	40000.00
Access Road	1.00	JOB	102,000	0	0	102,000	102000.00
Design, 7%	1.00	JOB	12,400	0	0	12,400	12400.00
Contingencies, 20%	1.00	JOB	37,900	0	0	37,900	37900.00
TOTAL PARKING LOT SITE PREPARATION	1.00	JOB	227,300	0	0	227,300	227300.00
TOTAL NON-FEDERAL COSTS	1.00	JOB	2,606,100	16,033	82,569	2,704,702	2704702
TOTAL OCEAN/PARKING LOT ALT C2	1.00	JOB	30,249,623	539,904	3,000,772	33,790,299	33790299

BASIS OF COST
OCEAN/PARKING LOT ALTERNATIVE C2

1. Project Description: The project consists of deepening Richmond Harbor to a project depth of -38 feet mean lower low water with a tolerance (overdepth) of 1 foot below project depth, except for areas of hard material where dredging will be -38 feet plus 1 foot overdepth and up to one foot of tolerance.

Approximately 1,496,000 cubic yards of soft material and 181,000 cubic yards of hard material would be dredged and deposited at the EPA approved Ocean disposal site.

Approximately 219,000 cubic yards of unsuitable soft material, 15,000 cubic yards of unsuitable hard material and approximately 7,000 cubic yards of underwater rock would be dredged and deposited at the local sponsor's Parking Lot upland disposal site.

2. Pricing is based on the January 1996 price level. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (Costs have been escalated from the previous January 1995 price level using an escalation factor of +3.0%). The estimate assumes that the Contractor will be working 24 hours a day, 7 days a week.

3. For disposal at the Parking Lot disposal site, initially the dredged material and the rock would be unloaded by the 2nd clamshell dredge at the drying area (approximately 8 acres) which is adjacent to the Parking Lot area. The material would then be loaded onto dump trucks and hauled to the Parking Lot area (approximately 46 acres) and spread and dried. The local sponsor has provided the costs for site preparation, handling, hauling, spreading and drying the materials.

4. Real estate costs were obtained from the Sacramento District, Real Estate Division.

5. The estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract by a prime contractor who will execute all the dredging, hauling and disposal operations unless noted otherwise.

6. Mobilization and demobilization for plant and equipment is based on the preparation, transfer, set-up and removal of plant and equipment required. It is assumed that moblilization and demoblization of all equipment can be completed in 14 days.

7. Dredging and disposal at the Ocean disposal site would be performed by a 20 cy clamshell dredge, 6-4,000 c.y. bottom dump scows, 5-2,300 Hp hauling tugs, 1-850 Hp support tug, other support equipment. The dredge/haul production rate is approximately 360 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

Dredging and disposal at the Parking Lot disposal site would be performed by a 20 cy clamshell dredge, 3-4,000 c.y. bottom dump scows, 2-1,200 Hp hauling tugs, 1-850 Hp support tug, other support equipment and a 2nd clamshell plant is used at the Parking Lot disposal site to unload to material. The dredge/haul production rate is approximately 620 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

For all dredging and disposal operations, the number of scows required is determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. Barges would be filled to 80% capacity and no overflow is allowed. Tugboat speed for the round trips is assumed to be 6 knots average speed.

8. Underwater rock would be excavated using the same clamshell plant and equipment with a 9 cy bucket and a 2nd clamshell plant is used at the Parking Lot disposal area to unload to rock. Production rate would be approximately 70 cy/hr.

9. Hauling distance from the dredge site to the Ocean disposal site is approximately 72 miles.

Hauling distance from the dredge site to the Parking Lot disposal site is approximately 1 mile.

10. Construction Time. The project can be completed in 9 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

OCEAN/PARKING LOT ALTERNATIVE C2

Contingency Footnotes:

1/ Mobilization and demobilization costs are dependent on the location and availability of plant and equipment at the time the project is bid. A project of this magnitude will likely attract bidders from the East Coast. Availability of plant and equipment may be impacted by other jobs in progress in the local area such as annual maintenance dredging and the Oakland Harbor deepening project which will be in progress when this project is scheduled to commence.

2/ Clamshell dredging costs are dependent on the characteristics of the material to be dredged which affects production rates. Other unknown factors which will affect the dredging costs are marine traffic and weather conditions, especially for ocean disposal.

3/ Aids to navigation cost is dependent on the number of buoys and markers to be relocated and the number of safety markers to be installed during the project in accordance with marine regulations and as directed by the Coast Guard.

4/ For Ocean disposal monitoring, the cost is based on a quote from a private firm for ocean site monitoring for the Oakland Harbor deepening project and is subject to change based on the extent of actual monitoring requirements when the project is awarded.

5/ Rock removal costs are dependent by the amount and condition of the rock. The information on the amount of rock is preliminary and no information is available on the effort necessary to break the rock.

FEDERAL & NON-FEDERAL
COST ESTIMATE
RICHMOND HARBOR -38' DEEPENING
ALCATRAZ/GRAVING DOCKS ALTERNATIVE D
SUMMARY OF FIRST COST FULLY FUNDED

ACCOUNT CODE	ITEM	ESTIMATED COST SUBTOTAL JAN 96 $	CONTINGENCY	ESTIMATED COST TOTAL JAN 96 $	FULLY FUNDED ESTIMATE ESCALATION JAN 97 MDPT CONST	FULLY FUNDED ESTIMATE TOTAL $
FEDERAL COSTS						
01------	LANDS & DAMAGES	$60,800	$4,200	$65,000	$1,560 *	$66,560
12------	NAVIGATION, PORTS & HARBORS	$6,812,514	$1,144,887	$7,957,401	$238,722	$8,196,123
30------	PLANNING, ENGINEERING & DESIGN	$9,503,850	$0	$9,503,850	$285,116	$9,788,966
31------	CONSTRUCTION MANAGEMENT	$540,750	$0	$540,750	$16,223	$556,973
	OPERATIONS & MAINTENANCE	$36,948	$5,542	$42,490	$1,275	$43,765
FEDERAL COSTS, TOTAL		$16,954,862	$1,154,629	$18,109,491	$542,895	$18,652,386
NON-FEDERAL COSTS						
01------	LANDS & DAMAGES	$1,743,000	$602,000	$2,345,000	$56,280 *	$2,401,280
12------	NAVIGATION, PORTS & HARBORS	$10,367,611	$460,446	$10,828,057	$324,842	$11,152,899
NON-FEDERAL COSTS, TOTAL		$12,110,611	$1,062,446	$13,173,057	$381,122	$13,554,179
FEDERAL & NON-FEDERAL COSTS, TOTAL		$29,065,473	$2,217,075	$31,282,548	$924,016	$32,206,564

*Real Estate costs are escalated to the Certification date for LERRDS, 7/96.

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** DETAIL SUMMARY OF FIRST COST **

		QUANTITY UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
	ALCATRAZ/GRAVING DOCKS ALT D						
	FEDERAL COSTS						
01------	LANDS & DAMAGES, GRAVING DOCKS						
01------	SUNK COSTS - Planning	1.00 JOB	2,800	0	0	2,800	2800.00
0121----	FEATURE DESIGN MEMORANDUM (FDM)						
01210301	Real Estate Supplement/Plan	1.00 JOB	20,000	0	1,500	21,500	21500.00
01210302	Gross Appraisal/Report	1.00 JOB	12,000	0	800	12,800	12800.00
01210303	Prelim Real Estate Acquistn Maps	1.00 JOB	8,000	0	600	8,600	8600.00
01210304	Physical Takngs Analysis Reports	1.00 JOB	2,000	0	100	2,100	2100.00
01210307	All Other Real Estate Analy/Docs	1.00 JOB	3,000	0	200	3,200	3200.00
0123----	CONSTRUCTION CONTRACT DOCUMENTS						
01230302	Real Estate Acquisition Document	1.00 JOB	4,000	0	300	4,300	4300.00
01230317	Real Estate LERRD Crediting Docs	1.00 JOB	8,000	0	600	8,600	8600.00
01230318	Real Estate All Other Documents	1.00 JOB	1,000	0	100	1,100	1100.00
01------	TOTAL LANDS & DAMAGES, GRAVING DOCKS	1.00 JOB	60,800	0	4,200	65,000	65000.00
12------	NAVIGATION, PORTS & HARBORS						
1202----	HARBORS						
120201--	Mobilization & Demobilization, Contingency 25%, Reason 1/						
	MOBILIZATION & DEMOBILIZATION						
	Mob & Demob, Clamshell	1.00 JOB	575,766	17,273	148,260	741,299	741298.73
	Mob & Demob, Hopper	1.00 JOB	350,435	10,513	90,237	451,185	451185.06
	TOTAL MOBILIZATION & DEMOBILIZATION	1.00 JOB	926,201	27,786	238,497	1,192,484	1192484
120215--	Clamshell Dredging, Contingency 15%, Reason 2/						
	SOFT DREDGING & ALCATRAZ DISP						
	Dredging, Hopper	1496000 CY	3,246,320	97,390	501,556	3,845,266	2.57
	SOFT DREDGING/GRAVING DOCKS DISP						
	Dredging, Clamshell	123000.00 CY	327,180	9,815	50,549	387,545	3.15
120215--	Clamshell Dredging, Contingency 25%, Reason 5/						
	Rock Excavation & Disposal	7000.00 CY	168,070	5,042	43,278	216,390	30.91
	HARD DREDGING & ALCATRAZ DISP						
	Dredging, Clamshell	181000.00 CY	1,705,020	51,151	263,426	2,019,596	11.16
	HARD DREDGING/GRAVING DOCKS DISP						
	Dredging, Clamshell	15000.00 CY	141,300	4,239	21,831	167,370	11.16

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	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
ALCATRAZ/GRAVING DOCKS ALT D							
FEDERAL COSTS							
120299-- Associated General Items, Contingency 25%, Reason 4/							
AIDS TO NAVIGATION	1.00	JOB	100,000	3,000	25,750	128,750	128750.00
30------ PLANNING, ENGINEERING & DESIGN							
E&D							
E&D, Dredging	1.00	JOB	230,000	6,900	0	236,900	236900.00
E&D, Alcatraz Site	1.00	JOB	10,000	300	0	10,300	10300.00
E&D, Graving Docks	1.00	JOB	55,000	1,650	0	56,650	56650.00
E&D, Sunk	1.00	JOB	9,200,000	0	0	9,200,000	9200000
TOTAL E&D	1.00	JOB	9,495,000	8,850	0	9,503,850	9503850
31------ CONSTRUCTION MANAGEMENT (S&I)							
SIOH, Dredging	7.00	MO	525,000	15,750	0	540,750	77250.00
OPERATIONS & MAINTENANCE	11210.00	CY	35,872	1,076	5,542	42,490	3.79
TOTAL FEDERAL COSTS	1.00	JOB	16,730,763	224,099	1,154,629	18,109,491	18109491

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		QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
	ALCATRAZ/GRAVING DOCKS ALT D							
	NON-FEDERAL COSTS							
01------	LANDS & DAMAGES, GRAVING DOCKS							
0123----	CONSTRUCTION CONTRACT DOCUMENTS							
01230302	Real Estate Acquisition Document	1.00	JOB	5,000	0	800	5,800	5800.00
01230305	Real Estate Appraisal Documents	1.00	JOB	8,000	0	1,200	9,200	9200.00
01230316	Real Estate Receipt Documents	1.00	JOB	1,730,000	0	600,000	2,330,000	2330000
01------	TOTAL LANDS & DAMAGES, GRAVING DOCKS	1.00	JOB	1,743,000	0	602,000	2,345,000	2345000
12------	NAVIGATION, PORTS & HARBORS							
1202----	HARBORS							
120215--	Clamshell Dredging, Contingency 15%, Reason 2/							
	DREDGING & ALCATRAZ DISPOSAL							
	6C, 6D, 7							
	Dredging, Clamshell	23000.00	CY	84,410	2,532	13,041	99,984	4.35
	DREDGING & GRAVING DOCKS DISPOSE							
	TERM 2							
	Dredging, Clamshell	22000.00	CY	58,520	1,756	9,041	69,317	3.15
	TERM 3							
	Dredging, Clamshell	15000.00	CY	39,900	1,197	6,165	47,262	3.15
	ARCO							
	Dredging, Clamshell	15000.00	CY	39,900	1,197	6,165	47,262	3.15
	GATX							
	Dredging, Clamshell	15000.00	CY	39,900	1,197	6,165	47,262	3.15
	GOLD BOND							
	Dredging, Clamshell	5000.00	CY	13,300	399	2,055	15,754	3.15
	LEVIN							
	Dredging, Clamshell	11000.00	CY	29,260	878	4,521	34,658	3.15
	TEXACO							
	Dredging, Clamshell	5000.00	CY	13,300	399	2,055	15,754	3.15
	TIME OIL							
	Dredging, Clamshell	5000.00	CY	13,300	399	2,055	15,754	3.15
	UNOCAL							
	Dredging, Clamshell	3000.00	CY	7,980	239	1,233	9,452	3.15
	TOTAL DREDGING & GRAVING DOCKS DISPOSE	96000.00	CY	255,360	7,661	39,453	302,474	3.15

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	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
ALCATRAZ/GRAVING DOCKS ALT D							
NON-FEDERAL COSTS							
120220-- Disposal Areas							
12022002 Site Work							
GRAVING DOCKS SITE PREPARATION							
BASIN 1	1.00	JOB	1,550,000	0	0	1,550,000	1550000
BASIN 5	1.00	JOB	1,550,000	0	0	1,550,000	1550000
BASINS 2,3	1.00	JOB	2,550,000	0	0	2,550,000	2550000
NEW WHARF AT BASIN 5	1.00	JOB	1,290,000	0	0	1,290,000	1290000
EXISTING WHARF AT BERTH 6A	1.00	JOB	1,130,000	0	0	1,130,000	1130000
TOTAL GRAVING DOCKS SITE PREPARATION	1.00	JOB	8,070,000	0	0	8,070,000	8070000
GRAVING DOCKS EXCESS MATERIAL							
OFF-LOAD, MUD AND ROCK							
Off-Load, Mud and Rock	64000.00	CY	64,000	0	0	64,000	1.00
Contingency, 20%	1.00	JOB	12,800	0	0	12,800	12800.00
Design, 7%	1.00	JOB	5,376	0	0	5,376	5376.00
Construction Support, 5%	1.00	JOB	3,840	0	0	3,840	3840.00
TOTAL OFF-LOAD, MUD AND ROCK	64000.00	CY	86,016	0	0	86,016	1.34
DECANT/DRY, MUD							
Decant/Dry, Mud	57000.00	CY	171,000	0	0	171,000	3.00
Contingency, 20%	1.00	JOB	34,200	0	0	34,200	34200.00
Design, 7%	1.00	JOB	14,364	0	0	14,364	14364.00
Construction Support, 5%	1.00	JOB	10,260	0	0	10,260	10260.00
TOTAL DECANT/DRY, MUD	57000.00	CY	229,824	0	0	229,824	4.03
TRUCK HAUL AND MATERIAL TESTING, Contingency 25%, Reason 6/							
Truck Haul to Vasco Rd. Landfill	64000.00	CY	1,572,546	47,176	404,931	2,024,653	31.64
Test Mat. for Vasco Rd. Landfill	57000.00	CY	11,734	352	3,021	15,107	0.27
TOTAL GRAVING DOCKS EXCESS MATERIAL	1.00	JOB	1,900,120	47,528	407,952	2,355,600	2355600
TOTAL NON-FEDERAL COSTS	1.00	JOB	12,052,890	57,721	1,062,446	13,173,058	13173058
TOTAL ALCATRAZ/GRAVING DOCKS ALT D	1.00	JOB	28,783,653	281,820	2,217,076	31,282,549	31282549

BASIS OF COST
ALCATRAZ/GRAVING DOCKS ALTERNATIVE D

1. Project Description: The project consists of deepening Richmond Harbor to a project depth of -38 feet mean lower low water with a tolerance (overdepth) of 1 foot below project depth, except for areas of hard material where dredging will be -38 feet plus 1 foot overdepth and up to one foot of tolerance.

Approximately 1,496,000 cubic yards of soft material and 181,000 cubic yards of hard material will be deposited at the Alcatraz open water disposal area.

Approximately 219,000 cubic yards of unsuitable soft material, 15,000 cubic yards of unsuitable hard material and approximately 7,000 cubic yards of rock would be deposited at the Graving Docks disposal site.

2. Pricing is based on the January 1996 price level. Plant and equipment costs are from the Corps of Engineers databases for Region VII supplied with the MCACES dredging programs. Labor costs are from the current State of California wage rate determination sheets (Costs have been escalated from the previous January 1995 price level using an escalation factor of +3.0%). The estimate assumes that the Contractor will be working 24 hours a day, 7 days a week.

3. Real estate costs for the Graving Docks disposal site are provided by Sacramento District real estate office. Site preparation costs for the Graving Docks are provided by the local sponsor and include site preparation, unloading the dredged material, processing, drying, hauling and placing the material from the drying area into the Graving Docks, engineering and design, construction management and contingencies.

4. The estimate assumes that the Contractor will dredge all of the tolerance yardage. The dredging will be performed in one contract by a prime contractor who will execute all the dredging, hauling and disposal operations unless noted otherwise.

5. Mobilization and demobilization for plant and equipment is based on the preparation, transfer, set-up and removal of plant and equipment required. It is assumed that moblilization and demoblization of all equipment can be completed in 14 days.

6. Dredging for material to be disposed of at the Alcatraz disposal area would be performed by a medium-size hopper dredge (3,800 c.y. capacity). The hopper dredge/haul production rate is approximately 590 cy/hr for soft material (Based on working 730 hours/month).

Except that material dredged from the berth areas and hard material areas would be performed by a 20 cy clamshell dredge, 3-4,000 c.y. barges, 2-1,200 Hp hauling tugs, 1-850 Hp support tug, and other support equipment due to the restricted areas. The clamshell dredge/haul production rate is approximately 450 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

Dredging for material to be disposed of at the Graving Docks disposal area would be performed by a 20 cy clamshell dredge, 3-4,000 c.y. barges, 2-1,200 Hp hauling tugs, 1-850 Hp support tug, and other support equipment. The dredge/haul production rate is approximately 620 cy/hr for soft material and 140 cy/hr for hard material (Based on working 730 hours/month).

The number of scows required is determined by balancing the dredge production rate and the hauling time of the tugs for optimum efficiency. Barges would be filled to 80% capacity and no overflow is allowed. Tugboat speed for the round trips is assumed to be 6 knots average speed.

7. Underwater rock would be excavated using the same clamshell plant and equipment with a 9 cy bucket. Production rate would be approximately 70 cy/hr.

8. Hauling distance from the dredge site to the Alcatraz disposal area is approximately 11 miles.

Hauling distance from the dredge site to the Graving Docks disposal area is approximately 1 mile.

9. At the Alcatraz disposal area, dredged material would be unloaded by bottom dumping from hopper and dump scows.

At the Graving Docks disposal site, the dredged material and rock would be unloaded by a clamshell. The capacity of the Graving Docks is only 178,000 cubic yards. Therefore the excess material, 57,000 cubic yards (235,000 - 178,000) and 7,000 cubic yards of rock would be loaded and hauled to a landfill which can accomodate unsuitable material. The cost of these operations at the Graving Docks site is included in the estimate as a Non-Federal cost.

10. Construction Time. The project can be completed in 7 months, including mobilization and demobilization, based upon the assumed plant and calculated production rates.

ALCATRAZ/GRAVING DOCKS ALTERNATIVE D

Contingency Footnotes:

1/ Mobilization and demobilization costs are dependent on the location and availability of plant and equipment at the time the project is bid. A project of this magnitude will likely attract bidders from the East Coast. Availability of plant and equipment may be impacted by other jobs in progress in the local area such as annual maintenance dredging and the Oakland Harbor deepening project which will be in progress when this project is scheduled to commence.

2/ Hopper dredging cost is dependent on the characteristics of the material to be dredged which affects production rate. Other unknown factors which will affect the dredging cost are marine traffic and weather conditions.

3/ Clamshell dredging costs are dependent on the characteristics of the material to be dredged which affects production rates. Other unknown factors which will affect the dredging costs are marine traffic and weather conditions.

4/ Aids to navigation cost is dependent on the number of buoys and markers to be relocated and the number of safety markers to be installed during the project in accordance with marine regulations and as directed by the Coast Guard.

5/ Rock removal costs are dependent by the amount and condition of the rock. The information on the amount of rock is preliminary no information is available on the effort necessary to break the rock.

6/ Hauling costs are dependent on the distance to the landfill, amount of tipping fee and condition of haul routes. Testing costs are dependent on material characteristics of the dredged material, material acceptance criteria and moisture content. No final landfill site has been selected.